MUSEUM OF PRACTICAL GEOLOGY
AND GEOLOGICAL SURVEY.

RECORDS

OF THE

SCHOOL OF MINES

AND OF

SCIENCE APPLIED TO THE ARTS.

VOL. I. PART II.

PUBLISHED BY ORDER OF THE LORDS COMMISSIONERS OF
HER MAJESTY'S TREASURY.

LONDON:
PRINTED FOR HER MAJESTY'S STATIONERY OFFICE.
PUBLISHED BY
LONGMAN, BROWN, GREEN, AND LONGMANS.

1853.

LONDON: PRINTED BY GEORGE E. EYRE AND WILLIAM SPOTTISWOODE,
PRINTERS TO THE QUEEN'S MOST EXCELLENT MAJESTY.

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NOTICE.

The Maps to which reference is made in the memoir of Mr. Beete Jukes on the Geology of the South Staffordshire Coal Field are those of the Ordnance Survey of Great Britain, coloured Geologically by the Geological Survey, and consist of the following sheets of those Maps:—

Sheet 54. N.W. Quarter Sheet.
— 62. N.W. N.E., S.W., and S.E. Quarter Sheets.
— 72. S.W. and S.E. Quarter Sheets.

The horizontal sections mentioned are sheets 23, 24, and 25 of those of the Geological Survey of Great Britain, containing nine coloured sections across the South Staffordshire Coal Field in different directions, on the true or natural scale (that for the heights and distances being the same) of six inches to the mile.

The vertical sections are sheets 16, 17, and 18 of those of the Geological Survey of Great Britain, containing 37 pit sections of various parts of the same coal field, on the scale of 40 feet to the inch.

These maps and sections are to be procured at the MUSEUM OF PRACTICAL GEOLOGY, Jermyn Street, London, or from Messrs. LONGMAN & Co., Paternoster Row, London.

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of the
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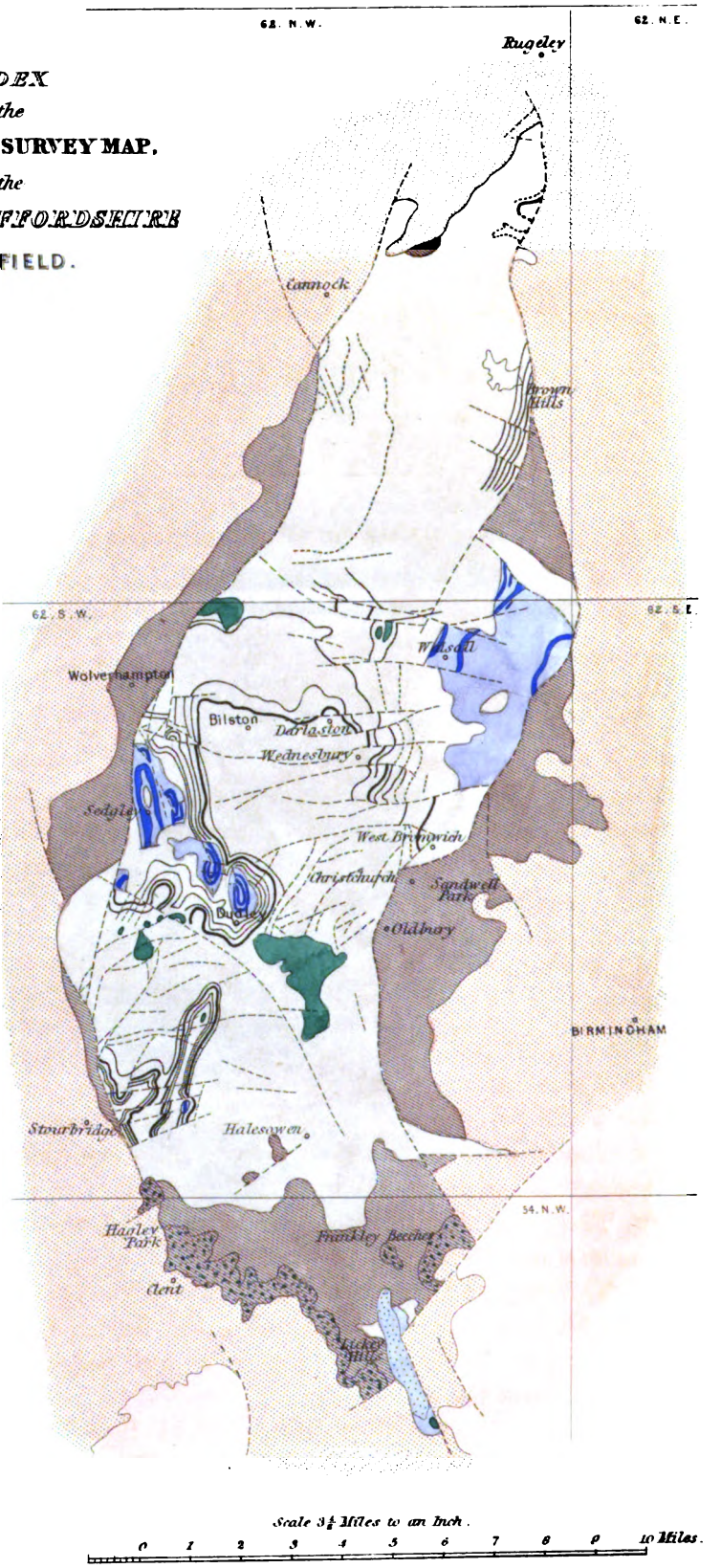
of the
SOUTH STAFFORDSHIRE
COAL FIELD.



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J. W. Lowry fc.

On the Geology of the South Staffordshire Coal Field.

By J. Beete Jukes, M.A. Camb., F.G.S., &c.

LOCAL DIRECTOR OF THE GEOLOGICAL SURVEY OF IRELAND.

Physical Geography of the District.

The district to be described in the following pages is the southern division of the county of Stafford, together with parts of the northern division, and of the adjacent counties of Shropshire, Worcestershire, and Warwickshire.

The most important portion of this district is the coal-field, which would be roughly described as the space included within a boundary line drawn from Rugeley through Wolverhampton to Stourbridge, thence to the southern end of the Bromsgrove Lickey, and returning through Harborne (near Birmingham) and Great Barr, back to Rugeley.

This tract of country is, for the most part, a gently undulating plain, having a mean height of between 400 and 500 feet above the sea. It rises occasionally into ridges or groups of hills, of which the principal are,—

1. The ridge of Bromsgrove Lickey, of which the highest point is said to be upwards of 900 feet above the sea.
2. The group of the Clent Hills, of which the highest point is about 950 feet above the sea.
3. The group of the Rowley Hills, of which the highest is about 820 feet above the sea.
4. The ridge of high ground running from Dudley to Sedgley, of which the most conspicuous points are Dudley Castle Hill, 730 feet; the Wren's Nest, 730 feet; and Sedgley Beacon, 760 feet, above the sea.
5. The high ground about Barr, of which Barr Beacon is the summit, and is about 800 feet above the sea.

6. The high swelling plateau of Cannock Chase, the highest point of which, Castle Hill, in Beaudesert Old Park, is 900 feet above the sea.*

As the district forms part of the water-shed of England it can, of course, have no navigable rivers; and its streams are few and unimportant. From the high ground that runs from Frankley Beeches to the Clent Hills, the little river Stour rises on the one side, running by Halesowen and Stourbridge, and thence to Stourport, where it joins the Severn, with which it flows into the Bristol Channel; while on the other side are the sources of the little river Rea, that flows through Birmingham into the Tame, and thence into the Trent and the German Ocean.

From Frankley Beeches, the water-shed runs through Rowley, Dudley, and Sedgley, to Wolverhampton. On the west of that ridge the streams run either directly into the Stour, or into the Smester Brook which rising just west of Wolverhampton runs nearly due south to join the Stour near Stourbridge. On the east of the ridge is the basin of the Tame river, lying between it and the high ground of Barr Beacon; the sources of this river are near Bloxwich, whence it runs south and south-east to Aston near Birmingham, and afterwards sweeps off northward to Tamworth, in order to join the Trent. In the northern part of the district, the drainage runs entirely into the Trent, the eastern brooks running directly into that river; the western streams flowing first into the Penk, which after joining the Sow near Stafford flows into the Trent at Great Haywood.

The river Trent, coming from the N.N.W. to this spot, bounds the district on the N.E., cutting it off by a very well marked and sudden depression; the mean height of the Trent valley here being not more than 250 feet above the sea.

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* These heights are only approximate; but they are believed to be within 20 or 30 feet of the truth.

CHAPTER I.

Description of the Rocks.

The rocks, or geological formations, entering into the structure of this district are—

Stratified Rocks.	1. The Lias. 2. The New Red Sandstone. 3. The Lower Red Sandstone, or Permian. 4. The Coal-Measures. 5. The Silurian Rocks.
Igneous, or Unstratified Rocks.	Basalt and Greenstone.

1. *The Lias.*

Although not strictly lying within the district, I mention this rock because its existence in Staffordshire was first discovered during the survey of the coal-field, and because it may have a rather important bearing on some of the theoretical results arrived at. It occurs on the high ground of Needwood forest. It consists of alternations of blue shale and limestone, the bands of limestone being not more than 6 or 8 inches in thickness, over which are some arenaceous beds becoming in the upper part a white shaly sandstone. The limestone bands have not yet been worked, but they would probably have the same hydraulic character as those of Barrow-upon-Soar.* My colleague Mr. Howell, however, who mapped this neighbourhood, informs me that the limestone here is more argillaceous, and not so pure as the lias limestone of other places, that near Stratford-on-Avon for instance. In the sandy beds are some imperfect casts of bivalve shells.

* My attention was directed to this lias district by my friend Mr. T. Turnor, of Abbotts Bromley, who had himself a suspicion of its true character from the observations of his friend Mr. E. Pickering.

2. *The New Red Sandstone.*

Without entering into the difficult and important question of the subdivision and description of the New red sandstone of England generally, it is possible to subdivide the New red sandstone of our district into three, namely,—

A. The red marls, containing occasional beds of gypsum and rock salt.

B. Intermediate beds of red, white, brown, or yellowish sandstone, with occasional bands of marl.

C. The brick-red sandstone, and quartzose conglomerates, in which bands of marl sometimes occur, but not often.

A. The Red Marls.—This subdivision is principally composed of marl of a dull red colour, with occasional thin blueish shaly beds, containing sometimes small layers of blueish white sandstone a few inches thick. In the bottom part of the marls occur occasional beds of sandstone some feet in thickness, of a brown, or yellow, or white colour, containing few or no pebbles, generally rather shaly, and not often marked by oblique lamination. The marls are likewise generally shaly, and are sometimes slightly arenaceous, especially in the lower beds. Like all marls, they, when dry, frequently crumble into small cuboidal fragments.

In Staffordshire neither the gypsum nor the salt of these rocks is very abundant. Beds of gypsum may be seen cropping to the surface in several places about Tutbury and Uttoxeter, and they are met with elsewhere in wells and pits. The salt is only known by the occurrence of brine springs, which are met with at two places, one at Silkmoor, 1½ mile south of Stafford, the other at Shirley-wych near Weston-upon-Trent. At the latter place there is a shaft sunk to the depth of 414 feet, giving the following section:—*

Drift sand and gravel	54	feet.
Gypsum	6	,,
Red marl	354	,,
	414	,,

* I am indebted for these details to my colleague Mr. Edward Hull, who surveyed the boundary of this subdivision in the maps of the district.

It is probable, therefore, that the total thickness of this subdivision cannot be much less than 600 feet.

B. The Intermediate Beds.—The red marls at their base commonly alternate with beds of whitish, or brown, or red sandstone. Occasionally the sandstone predominates, and forms a mass of white sandstone, perhaps 100 feet thick. Sometimes this becomes hard and capable of standing exposure to the weather, and it then makes a very tolerable building stone.*

Below this variable white band of sandstone which is very inconstant, and often passes into red sandstone, with or without marls, occur other sandstones of a dull red or brown colour, sometimes also white or yellowish. They sometimes contain small quartz pebbles, but rarely show any large beds of conglomerate. Beds of marl are interstratified with these sandstones, but are not very persistent, neither are they in any place of a greater thickness than 8 or 10 feet. In several parts of this subdivision, more especially in its lower portion, occur bands of calcareous sandstone. These are usually a mottled red and white concretionary rock, of which a large portion consists of carbonate of lime, so that in some places it was formerly burnt for lime. Little strings of calcareous spar traverse it in all directions. Bands 10 or 15 feet thick of this substance occasionally occur. It is not very unlike some of the more impure cornstones of the Old red sandstone. Fossil plants are found in this subdivision occasionally, but not, so far as I am aware, within our district, except in the neighbourhood of Bromsgrove, where Professor Ramsay informs me he has recently discovered them.

As to the thickness of this subdivision, no satisfactory estimate has yet been arrived at. If we trusted to the apparent dip of it over considerable distances, we should, in some places, assign it a thickness of nearly a thousand feet; in others, it seems scarcely to have a greater thickness than 100 or 200 feet.

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* The new church called St. Matthew's in Wolverhampton is partly built of stone derived from these beds at King's Wood, near Albrighton, as is also the new Roman Catholic church at Rugeley, the stone for which was quarried near "the Stone House," about one mile to the west of the town.

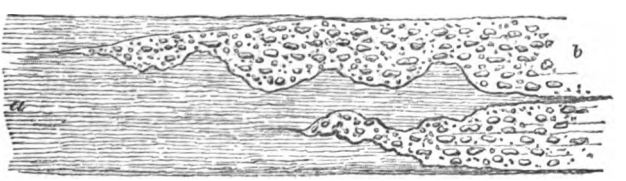
Like almost all sandstones, it is greatly characterized by the structure called "false bedding," or, as it may often be better termed, "oblique lamination." This structure is frequently so extensive, as even in a very considerable section (a road cutting, for instance, 50 yards long and 10 or 15 feet deep) to deceive the observer who is not greatly on his guard, and induce him to take that for the real dip of the formation which is truly but the slope at which the materials composing it were originally deposited. As a general rule, it is only safe to rely on the thin marl bands and partings when making observations on the dip of any portion of the new red or other sandstone. Even these, however, will occasionally deceive the most practised observer, and are never to be implicitly relied on as giving results true within less than 5°.

C. The Brick-red Sandstone and Quartzose Conglomerate.—In many of the sections in our district, immediately below the beds described above, may be seen a thick mass of soft sandstone, very fine grained, and of a brick-red colour. This sandstone may be well seen in the new cemeteries at Birmingham, in the cuttings of the roads about Tettenhall and Compton near Wolverhampton, and in the road cuttings about Stourbridge, and at other places. This brick-red sandstone passes downwards and sometimes laterally into a thick mass of conglomerate of quartz pebbles. It appears generally as if the soft brick-red sandstone were fairly over the conglomerates. Sometimes, however, there is little or no conglomerate between the last subdivision and the Lower new red; sometimes there seems to be little but conglomerate, and in one or two instances the conglomerates seem to be above the brick-red sandstone. That the conglomerates are very irregular, both in thickness and extent, we should expect from their very nature, and from the analogy of all other conglomerate beds. It is, however, a remarkable fact, that it is scarcely possible to pass from the coal-field to the upper parts of the New red sandstone, without traversing a band of conglomerate somewhere on the horizon of the subdivision we are now describing.

The pebbles found in these conglomerates consist principally of brown or liver-coloured quartz rock. Most of them are doubtless fragments of the altered Caradoc sandstone of the Lickey, and in some, casts of small *orthis* or similar shells may be detected. Others, however, appear to be hardened coal-measure sandstone or mill-stone grit, *stigmaria* markings being sometimes discernible

in them. Others, again, are fragments of chert, often containing "screw-stones" or casts of crinoidal stems. Pieces of dull red sandstone, perhaps Old red sandstone, may occasionally be observed, and there are occasional pebbles of trap and of several other kinds of rock, especially agates, more or less decomposed and exfoliating in concentric coats. These conglomerates have all a rather stratified character, the pebbles lying with their longer diameters in the plane of the bedding, and bands of large and small pebbles alternating often with much regularity. Small beds of red sandstone also frequently occur in them, a foot or so in thickness. The conglomerate is always more or less incoherent, the pebbles being easily detached from the matrix, and it never has the hardened firmly-compacted character that some other conglomerates in both older and newer formations possess. It still retains its original character of *gravel*, and wherever it is found at the surface it is always spoken of and used as a gravel bed. That it is, however, really of the age of the New red sandstone is abundantly proved by many sections, showing that it both passes into and under beds of that formation. Of these sections the two following figures are examples:—

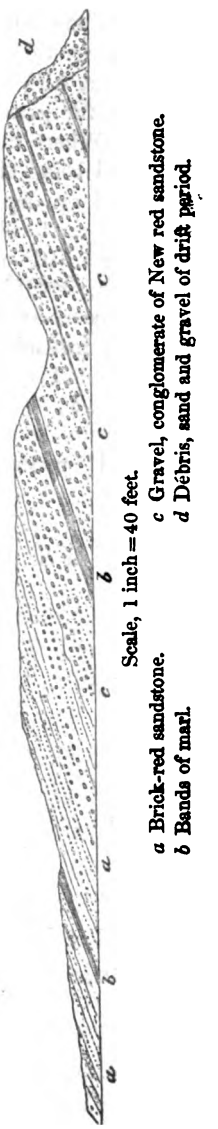
Fig. 1.—Canal cutting near Brown Hills, Cannock Chase.



Scale, 1 inch = 10 feet.

a Fine grained brick-red sandstone.
b Gravel, conglomerate of the New red sandstone.

Fig. 2.—Road cutting near Wordesley.



Scale, 1 inch = 40 feet.

a Brick-red sandstone.
b Bands of marl.
c Gravel, conglomerate of New red sandstone.
d Débris, sand and gravel of drift period.

As to the exact thickness of this subdivision, we have the same difficulty in arriving at a correct estimate as in the last subdivision. It must, however, be at least 400 or 500 feet, and may be much greater in some places.

It is at first, sometimes, very difficult to distinguish between these ancient gravels of the New red sandstone period, and the other gravels that belong to the much more modern era of "the Drift." In examining a gravel pit for this purpose, the first thing to look for is a chalk flint. True chalk flints, with chalk fossils, may be, in some places, pretty abundantly found in the gravels of Staffordshire, as sometimes also oolitic and liassic fossils.* Where these occur, they are, of course, conclusive evidence against the gravel being of the New red sandstone period. Very often, however, there are large deposits of "drift" gravel in which no fragments of rock are found that can be identified as newer than the coal-measures; still even these may after a little practice be distinguished from the "new red" gravels by their more irregularly heaped-up character; by the sand being of a paler and yellower colour than that of the "new red"; by the pebbles lying edgeways instead of horizontally; and by a vague but sufficiently appreciable general appearance, which a little practice enables one to recognize. My colleague, Mr. Hull, remarked to me that the pebbles out of the "drift" gravels were usually *dirty* when you got them out, while those out of the "new red" gravels were *clean;* a distinction that I have no doubt is often a true one.

3. *The Lower Red Sandstone, or Permian Rocks.*

If the survey had been confined to the immediate neighbourhood of the South Staffordshire coal-field it would have been impossible to have obtained sufficient evidence for establishing a boundary between the New red and the Lower red sandstone. In North Staffordshire, however, I believe, better sections exist, and my colleague, Mr. Hull, in examining that district, was enabled to acquire a knowledge of the characteristic distinctions of the two formations, which he afterwards brought to bear on the examination of our district. Prof. Ramsay, Local Director for Great Britain, visited North Staffordshire with Mr. Hull, and afterwards went over part of the South Staffordshire district

* *Gryphæa incurva*, and large fragments of ammonites and other fossils, are sometimes found in great abundance in red drift clay near Wolverhampton and other parts of the district.

with Mr. Hull and myself. The description of this formation, therefore, must be taken as the result of our joint labours.

It is as well to premise that the lithological distinctions between the rocks of this formation and those of the New red sandstone are often extremely vague and sometimes exceedingly small. This is more especially true with respect to the second or intermediate subdivision of the New red sandstone, the dark brown or pale red sandstones of which, with their interstratified marls and calcareous bands, are scarcely distinguishable by any lithological characters from similar beds in the Permian formation. There are, however, we believe, no brick-red sandstones, and scarcely any quartzose conglomerate to be found in the Permian formation; whenever, therefore, we get the above-named doubtful beds in our district we determine their geological horizon simply by their place with regard to the brick-red sandstones and quartzose conglomerates. There are two parts of the district from the examination of which it is possible to arrive at a tolerably complete notion of the structure and sequence of the Permian rocks,—namely the country about the Lickey and Clent Hills, and the neighbourhood of West Bromwich.

The country about the Lickey and Clent Hills.—The south end of the Lickey Hill, that on which the obelisk stands, is composed of the quartzose conglomerates and red sandstone, believed to be the base of the New red. On the northern end of the Lickey, about Square Coppice, as also on all the summits of the high ground of Segban, Romsley, Frankley Beeches, and the higher parts of the Clent Hills, where we get what appear to be the highest of the Permian beds in their respective localities, we find these beds to consist of a remarkable trappean breccia. This breccia is principally made up of angular fragments of porphyritic and syenitic trap, but almost equally angular fragments of many other rocks are found in it. A good section of this trappean breccia is shown in a road cutting just north of the brook in the lane leading from the Bell Inn, at Northfield, to Bangham Pit. The matrix of the breccia is here a brown sandstone, in places calcareous, interstratified with thin bands of marl. The imbedded fragments,

some of which are slightly rounded, but the majority remarkably angular, vary in size from mere grains to blocks a foot or a foot and a half in diameter; they consist of porphyritic trap in many varieties (but no basalt or greenstone), of sandstone of various kinds, of quartz-rock, and of Silurian limestone and sandstone, some of which was certainly Caradoc sandstone, not at all altered. There were slabs of these Silurian limestones and sandstones at least 1 foot square and 5 or 6 inches thick, with their edges scarcely at all rounded. The whole mass has a well-stratified character, and in some places is firmly compacted together by carbonate of lime, but in others is more or less incoherent. In other places these great slabs are not visible, perhaps for want of section; the whole breccia seeming to consist almost entirely of angular fragments of the trap.

In the Clent Hills the breccia has a red marly base, and is made up of large and small angular fragments of a dull red porphyry or syenite, often much decomposed, and splitting along concealed joints, so as to expose no fresh fracture; of fragments of greenstone; of one or two kinds of sandstone; "with several fragments of a porcellanic looking slaty rock, like some of those west of the Stiperstones. Near St. Kenelm's chapel this breccia passes down into 1, red marl, with small brecciated fragments at the top; 2, red sandstone; 3, red marl; 4, calcareous sandy rock."*

On Romsley Hill, going down into Hunnington, just below the trappean breccia was found a dull brown sandstone, with a band of calcareous concretionary sandstone. Near a place called Newtown, about a mile to the east of that, are quarries where a similar concretionary calcareous sandstone (a regular cornstone) has even recently been burnt for lime. In going down the brooks from this point to Twylands and Cooks Woods, we get numerous alternations of brown, or brownish grey, or purple, or pale salmon-coloured sandstones, sometimes thick-bedded, sometimes flaggy, with beds of marl, either dark purple with light-coloured spots or blood-red. Many of the sandstones

* Professor Ramsay's MS. Notes.

are calcareous and concretionary, and might be mistaken for some of the cornstones of the old red. A dark purple sandstone, with minute white specks, is a characteristic bed. All these beds are apparently horizontal, being successively exposed only by the rapid fall of the ground; and near the bottom of the slope, the blueish grey sandstones and shales of the coal-measures appear from underneath them, likewise in a horizontal position.

The neighbourhood of West Bromwich.—In the cutting of the Birmingham and Dudley railway, south of Sandwell Park, we see rising to the west from under a thick mass of quartzose conglomerate a series of brown and pale sandstones, with merely a few small and slightly angular pebbles. In these beds are masses, believed to be *in situ*, of a singular calcareous conglomerate that is better shown in other places. Under them, we have other pale sandstones alternating with bright red marls, all rising to the westward at an angle of about 10°. We have an account of a boring made hereabouts near "The Ruck of Stones" some years ago, by Mr. J. W. Unett (see Vertical sections, sheet 18, No. 24), consisting entirely of alternations of red, brown, and grey sandstones of various degrees of hardness, with many beds of red marl, mottled clunch, and other similar materials, all evidently belonging to the formation we are now describing. The depth of the boring was 221 yards 1 foot, or 664 feet.

Nearly a mile west of this, and therefore commencing in much lower beds than are seen in the railway cutting, we have several deep coal pits, the most remarkable of which are those recently sunk by Messrs. Davis at Bullocks farm, near Sponlane (see Vertical sections, sheet 18, No. 25). In these pits they passed through a mass of sandstones and marls belonging to this formation, 262 yards 2 feet, or 728 feet thick, or deducting the odd 28 feet for surface drift, &c., 700 feet of Permian, a good part of which at all events, if not the whole, must be below the 660 feet passed through at the "Ruck of Stones." What makes the section of these pits most remarkable, however, is that there occurred in them a small seam of *true Permian coal.* The following is an abstract of the upper part of the section,—

	FT.	IN.
1. Sand, &c.	28	6
2. Alternations of red sandstone with red and mottled marls and clays	169	0
3. Fireclay	3	0
4. White binds	12	0
5. Little coal	0	10
6. Fire clay	3	8
7. Red clay and sandstone	28	0
8. Dark and pale red sandstones	213	6
9. Alternations of red and white sandstone, with red and mottled clays and marls	270	0
	727	6

I saw masses of the fire-clays Nos. 3 and 6 on the pit bank while these pits were being sunk, and they did not differ either in colour or in any mineral character from the fire-clays of the coal-measures, except in having small calcareous nodules interspersed through them. These nodules were carefully searched for fossils, but none were discovered. In the red sandstones below, however, numerous rough casts of the large stems of plants, something like rude *sigillariæ* occurred.* Part of the 10-inch coal was shaly and rotten, but about 2 inches of it is a beautifully bright coal, highly bituminous, very brittle, with curious circular concentric concretionary markings.

At Lord Dartmouth's pits at West Bromwich Heath, there appears to be 268 yards 2 feet, or 806 feet, of Permian rocks, alternations of red sandstone and marl, but without any grey fire-clay and coal. At the Lyng colliery there was 550 feet, at the Lewisham pits 315 feet, and at the Terrace pits, close to the fault, they had 135 feet of "red rock" (see Horizontal sections, sheet 25, No. 7).

It appears then that there must be in the neighbourhood of West Bromwich, at the very least a total thickness of 1,500 feet, composed of the rocks of this formation.

* These large stems of plants, as also the pale sandstone in which they lay, were exactly similar to those got by Professor Sedgwick from the Lower red sandstone under the Magnesian limestone in the county of Durham, specimens of which are in the Woodwardian museum at Cambridge.

I have yet to describe the calcareous conglomerate mentioned above. This is well shown at Barnford Hill, two miles south of Oldbury, and thence to Brand Hall. It is composed almost entirely of rounded and semi-rounded fragments of mountain limestone and chert, with some pebbles of sandstone that may be millstone grit. It is about 20 feet thick, and is in several places quarried and the limestone pebbles burnt for lime. It occurs again in a field opposite the Gough's Arms, at Great Barr, as also in Baggeridge woods on the west side of the coal-field.

Besides this calcareous conglomerate, many of the sandstones sank through in the pits, or exposed in the quarries and cuttings, are very calcareous, like those before described in the district south of the coal-fields.

The reader must be pleased to bear in mind, that these descriptions of the Permian and New red sandstone rocks are meant to apply solely to the district of the South Staffordshire coal-field and its immediate neighbourhood. The Permian rocks of the neighbourhood especially are believed to be very variable, both in lithological character and in thickness, with perhaps many frequently recurring characteristics, but no uniformity. The thickness of the formation is believed to vary almost indefinitely within the limits of 1,000 or 3,000 feet.

4. *The Coal-Measures.*

The Coal-measures of North Staffordshire consist very largely of argillaceous (or clayey) materials, more or less mingled (or alternated with) arenaceous, bituminous, or other substances. These different beds have various local names, of which the following is a nearly complete list:—

Clunch,— a tough clay, or marl, breaking into blocks; sometimes rather sandy, generally grey or yellowish.

Binds,—shaly clay, close, smooth, compact, and splitting into regular laminæ, generally blue, or some shade of grey.

Clod, ground, earth,—earthy clay, generally of a blue or black colour.

Batt or bass,—highly bituminous shale, commonly very compact, and splitting into the finest laminæ, almost in-

variably black, and often interstratified in layers with the coal.

Fire-clay,—clay having a certain proportion of silica in its composition, and therefore capable of making fire-bricks. It is generally unctuous to the touch as soon as it is got, which the other argillaceous beds rarely are. It is commonly a brownish grey, sometimes nearly black, but sometimes quite pale.

The siliceous or arenaceous beds of the coal-measures have the following local names:—

Rock.*—All sandstones having any degree of hardness or toughness go under this name with the colliers.

Pebbley or bibbley rock,—sandstone with pebbles, conglomerate.

Rotch, or roach, is applied to sandstone when it is softer or more brittle than rock, so as to break easily into small fragments.

Peldon,—a very hard, smooth, compact, flinty stone, with conchoidal fracture.

Some of these terms are used in composition to describe beds partaking of both characters, as—

Rock-binds,—sandy shale or shaly sandstone.

Clunch-rock,—hard sandy clay, &c. &c. &c.

They have also terms to distinguish impure coal, such as slumms, smut, &c.

Under the term "stone" they usually include all ironstones; and whenever the term stone is used alone, ironstone must be almost invariably understood.

Parting and pricking mean the thin layers between the more important beds; they are generally some variety of clay.

The way in which the various beds of clay, shale, sandstone,

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* Under the term "rock" the miners likewise include all kinds of trap which occur in the district, using generally the distinctive terms "green rock" and "white rock," according to the colour. The only practical ambiguity that arises from this confusion of terms is in the case of the "white rock"; as, when that term is used, it is sometimes doubtful whether white sandstone is meant or white felspathic trap.

coal, and ironstone are interstratified with each other, may be seen by reference to the three published sheets of Vertical sections, Nos. 16, 17, and 18. It will suffice here to state, that in South Staffordshire, as in all other places, the Coal-measures are made up of a great series of alternating beds of these materials, —all of them varying in thickness and extent. As a general rule, the beds of coal are more constant in thickness, and extend over wider areas, than the beds of other materials. Next in constancy and persistency to the coals come the finest grained materials, such as the batts, and the finer varieties of fire-clay and clunch. The sandstones and coarser grained rocks are most capricious in their occurrence, and vary most suddenly in thickness and character. What distinguishes this district from all other coal-fields of England, and from most of those of the rest of the world, is the fact, that over a large part of it a number of beds of coal rest directly one upon the other, with little or no interstratified shales or sandstones till they make up the aggregate thickness of upwards of 30 feet of solid coal. This group of coal beds has long been celebrated under the name of the "Thick or ten-yard coal." It is not found in this form over the whole coal-field, but where it occurs it will serve as a convenient horizon in describing the Coal-measures; and we shall therefore speak of them first of all under three heads :—*A*. the beds above the Thick coal; *B*. the Thick coal; *C*. the beds below the Thick coal. We shall afterwards have occasion to observe, that, as in all other lithological descriptions, this one will only be true for a comparatively small locality, and that the very same beds rapidly alter their character and put on a totally new feature in the northern part of the field to what they have in the southern. The following description, therefore, is intended to apply firstly to the southern portion of the South Staffordshire coal-field, that part which lies south of a line drawn from Wolverhampton to Walsall. We will afterwards proceed to describe the less known district to the north of that line, and endeavour to show the precise nature of the connexion between the two.

A. Beds above the Thick Coal.—For the details of these beds the reader is referred to the Vertical sections, sheets 16, 17, and 18. They may be conveniently arranged as follows :—

BEDS ABOVE THE THICK COAL.

	Thickness in Feet.
1. Beds above the Upper Sulphur coal.	
2. The Upper Sulphur coal - - - -	0 to 1½
3. Intermediate measures - - - about	140
4. Little or Two-foot coal - - - -	1 to 2
5. Intermediate measures - - -	2 to 48
6. Brooch coal - - - - -	2 to 6
7. Brooch binds ironstone measures - -	7 to 20
8. Herring coal - - - - -	0 to 1½
9. The Pins and Pennyearth ironstone measures -	6 to 30
10. Intermediate measures, containing the "Thick coal rock" - - - - - -	38 to 157
11. Broad earth* and Catch earth and Batt - -	6 to 14

1. The beds above the Upper Sulphur coal.—The greatest *detailed* section of these that we have is one taken from the Trough pits at Burnt Tree, communicated from Lord Ward's office by the kindness of Mr. R. Smith, of the Priory, Dudley, (see Vertical sections, sh. 17, No. 14). They are there 273 feet thick,† consisting principally of clayey beds, called "blue ground," "mingled ground," and "fire-clay," together with some clayey sandstones and pure sandstones, called "fire-clay rock," and "rough rock." The same or similar beds occur in this part of the section in the mines about Corbyns Hall, Shut End, and Kingswinford; as also, at Great Bridge, near West Bromwich. As we go south, however, either to Oldbury on the east side of the Rowley Hills, or to Corngreaves, on the south-west, these upper beds appear to become more arenaceous, and contain much hard sandstone and conglomerate. This coarse and arenaceous character continues to the south in the country about Halesowen, in which district still higher beds come in than have been sunk through in any other part of the field; beds which

* These are generally called broad and catch *heath*. I believe "heath," however, to be merely a corruption of "earth." The colliers generally pronounce "earth" as "yerth," and for "earthy" I have often heard them say "yethy." The beds, also, commonly known as "heaths" I have often heard men call "yerths," or "hearths."

† This Upper Sulphur coal is there 343 feet above the Thick coal.

must be at least 900 feet, and the very highest 1,000 feet, above the level of the Thick coal.

At Mr. Attwood's colliery at the Hawne the depth of the shaft to the bottom of the Thick coal is 255 yards = 765 feet; but as the beds dip south at the rate of 3 inches in a yard, and they have driven a "gate-road" in that direction 450 yards without meeting any fault or change of dip, the end of the gate-road must be 112 feet below the bottom of the shaft. But inasmuch as the ground rises rapidly to the south, while the beds fall, that rise being at least 100 feet in the 450 yards, we get over the head of the gate-road a thickness of beds above the Thick coal of *not less than* 977 feet.* Let us, then, suppose the beds to be absolutely horizontal from the end of the gate-road to Hasbury Hill, south-west of Halesowen, which those near the surface certainly are for the greater part of the distance, we must still add another 70 feet for the rise of ground from the Hawne to High fields, Hasbury,† when we shall have a thickness of 1,000 feet between the uppermost beds seen there and the *top* of the Thick coal.

These very high beds are almost entirely sandstone, generally brown or yellowish; sometimes thick-bedded, sometimes flaggy, sometimes with partings of shale.‡ The uppermost beds seen in a cutting of the Hagley-road near Halesowen had large concretions of calcareous sandstone in them. Upon these upper Coal-measure sandstones repose, in Quarry Hill, some of the beds of the Lower red sandstone or Permian rocks, in apparent conformity, both being horizontal, but with no passage or transition beds, the red sandstones containing pebbles and sandstones, not only of the Coal-measures, but of coal itself. These upper brown Coal-measure sandstones stretch over all the country from

* To the original 765 feet we must add 112 for the fall of the beds, 100 for the rise of the ground = 977 feet: deducting 30 feet for the thickness of the coal, we get in round numbers 950 feet for the thickness above the coal.

† The Hawne pits are 370 feet above the sea. Captain Ibbetson made the spot at "H" of "High fields" in the Ordnance map 540 feet above the sea; difference = 170 feet.

‡ Many of the sandstones of the Coal-measures, especially those around High Haden and south of the Rowley Hills, as also those south of the Lye Waste, appear to be made up of the débris of igneous rocks, most probably of the waste of basalt and greenstone. Some of them likewise have a very ashy character. These characters are fully noted and described by Sir R. Murchison in the Silurian System.

Halesowen to Hodge Hill and the neighbourhood of Old Swinford, being frequently seen, generally in a horizontal position, in quarries and small cuttings.

The only attempt to pierce through them was made some years ago by Mr. Richards, of Wassel Grove, who sunk a shaft having the following section :*—

		FT.	IN.
1.	Sand rock and other rocks	123	0
2.	Blue rock-binds	4	0
3.	Sand rock	38	0
4.	Little coal	0	4
5.	Blue rock with black shades	5	0
6.	Grey peldon	0	8
7.	Rock binds	2	0
8.	Rough mingled rock	13	0
9.	Blue rock	4	0
10.	Fire-clay	6	0
11.	Soft white rock	13	0
12.	Bind measures with two ironstone bands	4	0
13.	Coal	1	6
14.	Fire-clay	4	0
15.	White rock	15	0
16.	Mingled ground with binds	5	0
17.	Rock with sheds (bored into)	45	0
		283	6

The coal No. 13 was said to be looked on as the Brooch coal by the miners, which is obviously impossible. If it be the same as any of the coals sunk through in other parts of the coal-field, it is most probably the Upper Sulphur coal; but this, both from its position and from the nature of the rocks above it, is exceedingly unlikely; and it is almost certainly a much higher bed even than this Upper Sulphur coal.† The beds at Wassel Grove are as nearly as possible horizontal; they crop to the south merely in consequence of the fall of the ground in that direction. No. 13 cropping into the brook that runs to Lutley Mill, at a distance of 704 yards from Wassel Grove.

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* Communicated by Mr. G. Thompson, of Corngreaves Hall.

† The Upper Sulphur coal is in no instance more than 343 feet above the Thick coal, and rarely more than 300 feet; but as the Thick coal is almost certainly 1,000 feet deep at Wassel Grove, and this coal (No. 13) is only 213 feet deep, it follows that it is between 700 and 800 feet above the Thick coal, and therefore cannot be the Upper Sulphur coal.

2. The Upper Sulphur coal is itself a small and insignificant bed, rarely if ever exceeding 1 foot 6 inches in thickness; it has never been "gotten," nor would it be worth the trouble of extracting. Like all other coals, it is local only, and is frequently altogether wanting in shafts that go through the beds in which it is found at other places.

3. The intermediate measures, between the Upper Sulphur coal and the Two-foot, have a mean thickness of about 140 feet, which thickness, wherever the two coals are undoubtedly present, does not seem to vary more than 37 feet. The variations in thickness seem to be due to the greater or less abundance of sandstones. The beds are chiefly argillaceous, being designated usually by the terms "bind," "clunch," "ground," "fire-clay," &c., but having several interstratified beds of various kinds of "rock." Like the beds (No. 1) before described, as we go south the sandstones begin to thicken and predominate, and become in some instances conglomeritic. In the Corngreaves district, indeed, although there are one or two little seams of coal here and there, there is no coal-bed that can be identified as the Upper Sulphur coal. We cannot, therefore, draw here any division between 1 and 3, the whole section above the Two-foot coal being alike in character.

4. Little or Two-foot coal.—Although this coal has never been worked or "gotten," its thickness not being sufficient to allow it to be got with profit, it is yet a very persistent bed, as its presence is noted in all the detailed pit sections we have which pass through its place. It varies from 1 to 2 feet thick, but I know nothing of its quality, nor whether any trials of it have been made.

5. Intermediate measures between the Little coal and the Brooch.—These beds are almost universally clunch, binds, fire-clay, or some argillaceous material; but in one or two cases they contain beds of rock or sandstone. Their thickness in all the central portion of the field varies from 13 to 48 feet, the mean being about 25 feet. As we go south and west, however, into the district of Corngreaves, Cradley, and the Black Delph, the thickness of these beds rapidly diminishes, and they vary only from 2 to 7 feet, consisting of fire-clay or batt, or both.

In some places in the neighbourhood of Kingswinford, as also in the district last referred to, a little coal makes its appearance occasionally in these beds, but is too unimportant to require a separate notice.

6. The Brooch coal.*—This is the uppermost workable coal in the coal-field; it is almost invariably of excellent quality, and in great request in the district for parlour fires. It varies in thickness from 2½ to 6 feet, the mean and by far the most usual thickness being about 4 feet. It is quite constant over the whole coal-field, wherever the beds occur in which it ought to be found.

7 and 8. Brooch binds ironstone measures and Herring coal.—These beds are almost entirely confined to one portion of the district, that, namely, on the west and south of Dudley. The Broach binds are shales averaging about 7 feet in thickness. In some places, as at Corbyns Hall, and Bromley Hall near Kingswinford, as also in the Corngreaves district, they contain ironstone nodules, which sometimes, but not always, are worth getting. About Brierly Hill and at Wordesley Bank Colliery they thicken out to upwards of 20 feet, and contain good ironstone. The Herring coal is generally about 18 inches thick, it is not worth getting; it is, however, very persistent in the district now described, and as we go towards High Haden we find other small coals, one of which is a cannel coal, coming in just below the Herring. Neither of these measures are mentioned in the section of the Oak-farm pits, nor in the borings at Holbeche Mill near Himley, on the west side of Dudley, nor do they occur at all on the east side of Dudley, except in one part of Tividale, where, in the record of an old sinking in 1797, communicated to me by Mr. Beckett of Wolverhampton, I find mentioned the following beds:—

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* Sir R. Murchison, in his account of this district in the Silurian System, derives this word from the measures having been first "broached" or entered on by this coal. Historically this was not the fact, as the first workings were along the crop of the Thick coal. I venture to conjecture that the name is derived from the old-used word "broche," a spit, as this coal makes an excellent fire for roasting at.

	FT.	IN.
a Broach coal - - -	3	9
b Black clunch - - -	7	0
c Coal - - - -	1	3
d Pennyearth with ironstone - -	7	0

of which *b* and *c* must be the beds we are speaking of.

9. The Pins and Pennyearth ironstone measures.—These take their names from the form of the ironstone nodules which they contain, the Pins being small round or cylindrical nodules, and the Pennyearth small flattish nodules. These measures have a wider spread than those last-mentioned, since they are noted in sections east of Dudley, not only at Tividale but at Burnt-tree and Tipton, as also at Oldbury, in which last two places a small coal called Pennycoal, about a foot thick, is sometimes found in them. Their thickness there is from 7 to 20 feet. I do not know how far these beds may have extended and been worked for ironstone formerly in the central portion of the coal-field between Dudley and Bilston, but they are now principally, if not solely, gotten in its south-western portion between Dudley and Stourbridge, especially in the district around Corbyns Hall and Brierly Hill, where they sometimes together attain a thick-ness of 27 feet; and at Wordesley Bank Colliery the Pins are 4 feet, and the Pennyearth 27 feet thick. They always occur also in the Corngreaves district, where they vary in thickness from 6 feet to 17 feet. It appears that the two measures are not always distinctly recognizable, as sometimes one sometimes the other only is mentioned; and moreover, that the presence of good ironstone is uncertain, so that in some instances where the measures exist they are not worth working, and therefore but little noticed. They are not mentioned at all in the sections of Holbeche Mill and the Oak-farm on the one side, nor at Netherend near Cradley on the other side of the south-western district; nor do I find them mentioned by name in the sections about Highfields and Bradley south of Bilston, nor in those of Great Bridge and the Swan towards West Bromwich. In some sections, however, as in the old one of Bradley mine, beds con-taining ironstone are mentioned as occurring a short distance below the Brooch coal, which are probably these measures.

10. Intermediate measures, containing the Thick-coal rock. —These measures, according to the details given in thirty-five pit sections, vary greatly, not only in widely separated parts of the coal-field, but often in places immediately adjacent to each other.

In part of the country just south of Bilston the question is complicated by the occurrence of the "Flying reed," which will be described presently. Supposing this Flying reed to be the top beds of the Thick coal, we have here only 90 feet between it and the Brooch, occupied entirely by "blue binds," while in the beds interposed between the Flying reed and the remainder of the Thick coal there occurs a rock or sandstone of considerable thickness. In the district east of Kingswinford, where the phenomenon of the Flying reed again occurs, we have the recurrence of similar facts.

Setting those exceptional cases aside, we have at Bradley about 60 feet of beds between the Brooch and Thick coals, of which the uppermost portion is clunch and rock binds, with ironstone, the lower, peldon and grey rock, 27 feet thick; while around Tipton, Burnt-tree, Tividale, Great Bridge, Oldbury, and West Bromwich, there is an average thickness of between 120 and 130 feet for these beds, the greatest thickness being 170 feet and the least 83 feet. Of this thickness 75 feet on an average is composed of "rock" or sandstone, the greatest amount of that material being 120 feet and the least not more than 20 feet. The method of its occurrence varies as much as its amount, as it is interstratified with more or less argillaceous materials in every possible way, except that the sandstone seems most generally to preponderate in the lower part of the mass.

In the south-western portion of the district the thickness of these beds also varies considerably. In the mines around Pennett, Corbyns Hall, and Shut End their total thickness varies from * 52 feet to 116 feet, the average being 85 feet. In those around Corngreaves (or between the Lye Waste and Rowley Regis) the least thickness is 109 feet, the average rising to

* Still exclusive of those mines in which the Flying reed occurs, when the thickness sometimes diminishes to 29 feet.

125 feet, while the greatest I know is 157 feet. Around Brierley Hill, on the contrary, and at Wordesley Bank and the Black Delph, the greatest thickness of these beds is diminished to 52 feet, they are sometimes as little as 38 feet, the mean being only 46 feet. In each of these cases the thickness seems to vary almost directly as the quantity of "rock" or sandstone. In the Corngreaves district the whole of these beds are almost entirely composed of rock and rock binds. Around Brierley Hill there is not more than 6 feet to 12 feet of rock, while round Corbyns Hall the quantity of rock is generally about half the whole mass, being more or less interstratified with beds of binds or clunch, which are generally described as "strong," meaning that the argillaceous is largely mingled with arenaceous or siliceous material. I do not know that any of these beds have acquired distinctive names, except that occasionally I have found near the bottom of them mention made of "Shooter's four measures," or "Shooter's greys."

11. Broad earth, Catch earth, and Batt.—I do not know why the first is called "broad"; "catch" earth, I presume, is so-called because immediately under it they catch the coal, but I have sometimes seen it written "cat earth," or rather "cat heath." These are beds known to the miners, and to them only, as they can only be seen while a shaft is being sunk, and then only just while it is passing through them. They are, I believe, earthy shales of a peculiar character. I have had them described to me as "clunchy stuff," and in other similar terms. They do not appear to be always present, or if so their presence is not always noted in the sections. Where they do occur, however, they are said to be always recognizable by their peculiar character. The total thickness of all three beds seems never to exceed 12 or 14 feet, the most usual numbers being 6 or 8. The "black batt," or hard bituminous shale, is generally about one foot thick, and rests directly on the upper surface of the coal; this seems to be almost invariably present even when there is no mention made of either of the other two beds. In the neighbourhood of Brierley Hill, and some other places, beds in this position, if not these beds, contain ironstone, the lowermost of which is called backstone, and is found in shale

immediately above the coal. The other is called ten foot stone, from its being found at that distance above the top of the Thick coal.

In the old Tividale section, mentioned before, the beds immediately above the Thick coal are as follows:—

	FT.	IN.
a Clunch and ironstone	2	9
b Black batt	6	0
c Coal	0	6
d Catch earth	2	9
e Batt	7	0
f Thick coal	31	6

In a section at Great Bridge, communicated by Mr. W. Matthews, I find these beds:—

	FT.	IN.
a Coal and batt	15	0
b Blue rock	16	0
c Thick coal	32	0

a and *b* being the most anomalous beds to rest on the thick coal of which I have seen any account.

B. The Thick Coal.—We come now to the description of a set of beds of high interest and importance both to the practical miner and the theoretical geologist. To the latter the careful study of these beds would, I believe, afford many materials for arriving at a better understanding of the question of the origin of coal in general than he now possesses. Some of these materials I may be enabled to lay before him.

The "Thick coal" consists of a number of beds of coal, varying from 8 or 10 to 13, resting eitheir directly one upon the other or separated by thin seams of "shale," or "clunch," called "partings." Each of these beds of coal is known to the miners by a particular name, and each has so much of a peculiar character that a block of it can be at once recognized by an old "thick-coal collier," and referred to its particular bed. How far that peculiar character extends I do not know, that is to say, how far a man taken from one pit to another, some miles off, would succeed in identifying blocks of coal on the pit bank; but I believe that some of the coals, more especially the lower

beds, could be identified by their mineral character alone almost through their whole extent.

As good typical sections of the "Thick coal" I will give two, taken from the central part of the district, one, given me by Mr. R. Smith from Lord Ward's office, of the Claycroft Colliery, at the Foxyards, about two miles north of Dudley; another, an old sinking in 1797, at Tividale, one mile east of Dudley, communicated by Mr. Beckett, of Wolverhampton.

Foxyards.	Ft.	In.	Ft.	In.
1. Roofs coal	-	-	4	6
Batt	0	9	-	
2. Top slipper	-	-	2	6
Batt	0	7	-	
3. White coal	-	-	3	9
4. Tow* (tough) coal	-	-	4	6
5. Brassils‡ coal	-	-	1	6
Batt	0	3	-	
6. Foot coal	-	-	2	0
Batt	0	3	-	
7. Slips coal	-	-	3	9
Hard stone	0	7	-	
8. Stone coal	-	-	4	6
9. Sawyer§	-	-	2	9
10. Slipper	-	-	3	9
Batt	0	6	-	
11. Benches‖ coal	-	-	3	0
	2	11	36	6
Total, with partings	-	-	39	5

Tividale.	Ft.	In.	Ft.	In.
1. Roof, or top floor	-	-	4	0
Parting, soft dark earth	0	4	-	
2. Top slipper, or spires	-	-	2	2
3. Jays coal	-	-	2	0
White stone parting	0	1	-	
4. Lambs coal	-	-	1	0
5. Tow (tough) or heath	-	-	1	6
6. Benches† coal	-	-	1	6
7. Brassils or corns coal	-	-	1	6
Foot coal parting	0	4	-	
8. Foot coal, or bottom slipper	-	-	1	8
John coal parting	0	1	-	
9. John coal, or slips, or veins	-	-	3	0
Hard stone	0	10	-	
10. Stone coal, or long coal	-	-	4	0
11. Sawyer, or springs	-	-	1	6
12. Slipper	-	-	2	6
Humphrey parting	0	1	-	
13. Humphreys coal	-	-	2	3
	1	9	28	7
Total, with partings	-	-	30	4

A few years ago the unusually thick coal at Foxyards was worked by "open work," as it there "cropped out" to the

* Pronounced to rhyme with "cow."

† This coal is but rarely noted; there is in many sections a coal called "fine floors," between the "white coal" and the "tow or heath."

‡ "Brassil" is a term generally used to denote a rough impure coal; sometimes it seems as if used to denote the presence of much iron pyrites, and to mean therefore "brassy"; it is not, however, always used in that sense.

§ There is very frequently here another coal called "Patchells," especially on the west of Dudley.

‖ This lowest coal is known by the various terms of Humphries or Omfray floor, benches, holers, kit, kid, or kick coal, and red coal.

surface, and was got out from a large quarry, exposing a cliff of coal 40 feet high and about 100 yards in length.

Proceeding from this central portion of the district, in every direction, we find several minor changes taking place in the constitution of the Thick coal. The individual beds, even where they are all present, vary frequently in thickness, and often in quality, in such a way, however, as to maintain the mean aggregate thickness of 30 feet over by far the greater portion of the district.

There are much more remarkable variations to be now noticed. In by far the larger portion of the extent of the Thick coal we find the upper beds consisting of—

1. Roofs, varying from 2 to 4 feet.
2. Top slipper or spires, varying from 2 to 3 feet.
3. White coal, generally about 3 feet.

Or sometimes the "Roofs" only is mentioned above the "white coal," with a thickness of 3 or 4 feet. If, however, leaving the central part near Dudley, we go towards the district between Bilston and Wolverhampton, we shall find the "white coal" forming the upper bed of the "Thick coal," and we shall get a separate bed of coal more or less removed from the "Thick coal," under the name of the "Flying reed coal." At Deepfields, near Coseley, we get the following section :*—

	FT.	IN.	
Flying reed coal	4	0	
Blue binds	54	0	} 84 feet.
Rock	30	0	
White coal	3	0	

under which come the "Tow," "Brassil," and the other measures of the Thick coal.

At Highfields, nearer Bilston, we have†—

	FT.	IN.	
Flying reed coal	3	6	
Sundries	54	0	
Do.	30	0	
Do.	89	11	} 204 ft. 3 in.
Rock	30	4	
White coal	3	0	
Tow coal	2	0	
&c.	&c.		

We thus get the top beds of the Thick coal separated from the rest by 84 feet in one case, and 204 ft. 3 in. in the other; the interposed materials

* Taken from the "Miner's Guide," published by Mr. T. Smith.

† From Smith's "Miner's Guide."

consisting of clay and sandstone. North of Highfields there is no mention at all of the Flying reed, it either having cropped out altogether, or being thrown out by the great Lanesfield fault.

Between Bilston and Wolverhampton, the "white coal" is always looked on as the top of the Thick coal. Here, however, we get still another change in the *central* part of the Thick coal, as a considerable mass of shale, sometimes containing ironstone, is interposed between the "foot coal" and the "slips coal."* This mass of shale, which goes by the euphonious appellation of "Hob and Jack," is 7 feet thick at Bradley Lodge just south of Bilston, and 10 feet at the Walling pits near Stow Heath, and at Ettingshall Lodge colliery. We have exhibited in these facts a great tendency in the Thick coal to split up towards the north, its different beds becoming separated from each other by the interposition of other materials. It will be seen hereafter that it is important to bear this tendency in mind.

If now we proceed from the neighbourhood of Dudley towards the west, we shall meet with very similar facts.

In going from Dudley to Kingswinford we find the Thick coal preserving a great uniformity of character for nearly three miles, varying but little from the following section:—

Section in the Horse-pasture, Corbyn's Hall.†

	FT.	IN.	FT.	IN.
1. Roofs coal	-	-	3	2
White coal parting‡	3	6	–	
2. White coal	-	-	3	9
3. Floors coal and batt	-	-	1	6
4. Heath or tow coal	-	-	3	6
5. Brassils coal	-	-	1	6
6. Fine coal	-	-	2	6
7. Veins coal	-	-	1	6
Stone coal parting	0	8	–	
8. Stone coal	-	-	3	0
9. Patchell's coal	-	-	1	0
10. Sawyer coal	-	-	2	0
11. Slipper coal	-	-	3	0
12. Benches or kid coal	-	-	2	5
	4	2	28	10
Total, with partings	-	-	33	0

* See Vertical sections, sheet 17; comparative sections of Thick coal at the bottom of the sheet.

† Supplied by Mr. W. Matthews.

‡ In other places, however, as at Dudley Woodside, &c., this "white coal parting" does not exist, and No. 1 rests directly on No. 2.

A little north of Corbyns Hall, namely, at Shut End colliery, and thence towards Kingswinford on the west, and Oak-farm on the north, we find a recurrence of the phenomenon of the "Flying reed" similar to that just noticed towards Bilston and Wolverhampton.

At the Dairy-pit in Shut End colliery we have the Flying reed coal 4 feet thick, resting directly on the white coal 3 feet thick, with the remainder of the Thick coal beneath it, forming a total thickness of solid coal 29 feet 4 inches, with only one 3-inch parting above the "stone coal." Proceeding to No. 5 pit, about 100 yards south of the Dairy-pit we get—

	FT.	IN.
Flying reed coal	4	0
Soft shaly parting	10	6
Thick coal	25	4

All the coals having exactly the same thickness as at the Dairy-pit, but 10½ feet of shale being interposed between the first and second. About 120 yards west-south-west of No. 5 pit we get at the New-engine pit*—

	FT.	IN.	
Flying reed coal	3	8	
Strong binds	5	4	45 ft. 9 in.
Dark clunch	9	3	
Mild clunch	24	8	
Dark shady clunch	6	6	
Thick coal	22	6	

And at another pit 60 yards farther from No. 5, in the same straight line, we have—

	FT.	IN.	
Flying reed coal	4	4	
Mild clunch	29	2	55 ft. 4 in.
Dark shady clunch	26	2	
Thick coal	24	3	

At Kingswinford, half a mile farther west, we get†—

	FT.	IN.
Flying reed coal	3	0
Sundry measures	128	0
‡ Thick coal	22	8

While at Oak-farm colliery, about half a mile north-north-west of Shut End, we have §—

	FT.	IN.	
Flying reed coal	2	6	
Strong binds	67	0	118 ft.
Rock (sandstone)	51	0	
Thick coal	24	0	

* The details of the Shut End colliery were supplied to me by Mr. Colly ground bailiff to Mr. Foster.

† From Lord Ward's office.

‡ This thick coal has many small partings between its beds.

§ Supplied by Mr. Grocott, ground bailiff.

Fig. 3.

The facts stated above are represented in figure No. 3, in which the original relative positions of the coals are drawn with as close an approximation to accuracy as the materials will allow. Whether any greater change takes place farther west and north is not known, as the beds are cut off in one case by the great western boundary fault, in the other by the out-cropping of the measures, and the consequent cessation of all works in each direction. On the south, the measures rapidly resume their normal condition, as represented in the Corbyns Hall section given above. That section may be taken as a sufficiently close description of the Thick coal over all the district between Kingswinford, Dudley, and Halesowen, allowance being made for frequent slight variations in the thicknesses of the different beds of coal and of the partings between them.

As we go down to the Lye Waste, however, near Stourbridge, and approach the boundary of the coal-field in that direction, we find a very remarkable change takes place in the character of the Thick coal, as it loses all its generally distinctive features and assumes those of the following section taken at Tintam Abbey fire-clay works :*—

	FT.	IN.	FT.	IN.
1. Top coal			7	0
Spoil (shale, &c.)	5	0		—
2. Middle coal			6	0
Spoil (shale, &c.)	5	0		—
3. Bottom coal			6	0
	10	0	19	0
Total, with partings			29	0

Here, then, as before on the north side of the district, we find a tendency in the Thick coal to split up into several groups of beds, which tendency, could we follow the beds farther, we should doubtless find still farther carried out.

In the pits at the Hawne colliery near Halesowen, the farthest south-easterly pits from the centre of the field, we again find the commencement of a similar splitting up, as there is a great thickening of the partings between the coals, although the subdivision is not so strongly exhibited as in the other instances given.

* Supplied by Mr. Skidmore, of Amblecote.

THE HAWNE COLLIERY.*

	FT.	IN.	FT.	IN.
1. Roof coal	-	-	1	6
2. Spires, or spin coal	-	-	2	7
3. White coal	-	-	3	0
Parting	2	0	-	
4. Heath or tow coal	-	-	3	0
5. Brassils coal	-	-	1	6
Parting	3	0	-	
6. Stone coal	-	-	3	0
Parting	1	0	-	
7. Patchells coal	-	-	1	6
Parting	0	8	-	
8. Sawyer coal	-	-	1	6
9. Slipper coal	-	-	3	0
Parting	1	6	-	
10. Benches coal	-	-	0	6
	8	2	21	1
Total, with partings	-		29	3

A very similar section to this, except that the partings are hardly so large, is that of Mr. Mills's colliery, about one mile north-by-east of the Hawne, just under the "B." of "Black Heath," in the ordnance map.

Mr. Mills gave it me as follows:—

	FT.	IN.	FT.	IN.
1. Roofs coal	-	-	1	6
2. Spires coal	-	-	2	9
3. White coal	-	-	3	0
Parting	0	9	-	
4. Fine floors coal	-	-	1	4
5. Tow coal	-	-	3	0
6. Brassils coal	-	-	1	6
Parting	0	6	-	
7. Fine coal	-	-	2	9
Parting	2	0	-	
8. Veins coal	-	-	2	0
9. Stone coal	-	-	3	0
Dunjack, hard parting	0	6	-	
10. Patchells coal	-	-	2	9
Batt	0	4	-	
11. Sawyer coal	-	-	1	4
12. Slipper coal	-	-	4	3
13. Benches coal	-	-	1	6
	4	1	30	8
Total, with parting	-		34	9

* Communicated by Mr. T. A. Attwood, of the Hawne.

Now, about three quarters of a mile east-south-east of this latter place, there was a deep pit sank some years ago by the Rev. E. Dudley, and the place was called the Black Heath colliery. The section of this pit was communicated to me by Mr. Benjamin Gibbons, of Shut End House, and is drawn in the 18th sheet of Vertical sections, No. 23. In this section they found the beds above the Thick coal in regular order, but thin and poor, the Brooch coal, for instance, being not more than 9 inches or 1 foot thick, instead of 3 or 4 feet. They passed through the Broad earth and Catch earth, the usual measures above the Thick coal, but below them they found—

	FT.	IN.
1. Soft parting	1	0
2. Black batt	6	0
3. Bad and rubbishy coal	7	5
4. Good coal	3	0
5. Brown batt and rock	10	0
6. Ditto, with ironstone balls	4	3
7. Batt	0	9
8. Coal	2	0

Of this section 3 and 4 must be taken to represent the Thick coal, 6 the Gubbin measures, and 7 and 8 the Heathen coal, hereafter to be described. We have here, then, the appearance of a great change and deterioration in the Thick coal, as indeed in the productiveness of the whole series, towards the south-east, proceeding from Dudley as a centre. If now we return to the neighbourhood of Oldbury, where the Thick coal beds have their normal character, we shall find, as we proceed to the south, towards this same Blackheath, that there is likewise a gradual thinning out of the Thick coal. At Mr. Chance's, No. 2 pit, between Park House and Titford reservoir, the Thick coal is only 27 feet thick, and it was said, when worked, to have thinned rapidly out towards the great boundary fault on the east, to only 7 feet, and even less.* Again, at Birchy-field colliery, between Portway Hall and Titford reservoir, the Thick coal is only 21 feet thick, the whole number of beds being described as present, but each a little thinner than ordinary; and further south, near Titford reservoir, the Thick coal was said to end altogether, either by gradual thinning or by the interposition of sandstone and shale beds.

I could not exactly determine the method of this disappearance of the Thick coal from the accounts given to me, and the underground workings were no longer accessible; it appears highly probable, however, that towards the south-eastern corner of the field, about Cakemoor, the Quinton, and the Leasowes, and in the singular narrow ridge of Coal-measures that runs up to the Stonehouse near Harborne, the Thick coal no longer exists,

* This information was communicated by Mr. Aaron Peacock.

except in a very debased form, and all the present evidence is *against* the productiveness of that portion of the field either in coal or ironstone.*

North of Oldbury I know of no important variation in the character of the Thick coal, either towards Tipton or Wednesbury, until we return to the district near Bilston already described.

In the Thick coal worked beneath the Lower red sandstone, or Permian of West Bromwich, the thickness is described as only 27 feet or 28 feet; but it appears to be all solid coal, with none but the most insignificant partings.

We will take this opportunity of examining one or two peculiar structures well exhibited in the Thick coal. The first of these peculiarities is known to the miners under the name of "rock faults." Of these, there seem to be two kinds: one, due to the denudation or partial destruction of the Thick coal subsequently to its formation, the cavity being filled up by other materials; the other arising from the deposition of sand or silt, during the formation of the Thick coal, and that sometimes in such quantity as nearly or altogether to preclude its existence; a great irregular mass or cake of sandstone, lying between the beds above and below *instead* of the coal.

Of the first kind of rock fault I have never had the opportunity of examining an example.

Mr. Aaron Peacock, however, described one to me as occurring a little west of Oldbury, in the Gower pits at the northern foot of the Rowley Hills. According to this description, which was very carefully given, there was a gap in the Thick coal 60 yards wide, and of much greater length. The bed on which the Thick coal rests is there called the "pouncill batt," and he described this as running under the Thick coal and across the gap the whole way with great regularity. The Thick coal was said to end on each side with a smooth slope, and the Broad earth or Cat earth above the coal was described as coming down over this slope, and running along *upon* the *pouncill batt* till it met the other slope, when it rose over it on to the top of the coal again. The distance from the point where the Thick coal first began to diminish in thickness to that where it ceased altogether was about 80 yards, which would give a slope of about 7°. The Cat-heath (or earth) above the coal is about 5 feet thick in the neighbourhood, with sandstone over it, varying in thickness from 12 to 30 yards. In some

* It must be recollected that the amount of this evidence is not great, and that there is *no known reason* why the measures may not recover their productiveness in as short a space on one side as the other.

places, however, there is no Cat-earth, and the sandstone rests directly on the coal. Over the above-mentioned gap in the Thick coal the sandstone is thicker than ordinary, and in one place it is 60 yards thick. The face of the slope of coal on each side of the gap was quite smooth, without any intermingling of the Cat-earth or sandstone with the coal. Unfortunately these workings were under water when the country was surveyed, so that it was impossible to verify this description, which I believe to be sufficiently accurate.

Of the second kind of rock fault I had fortunately a good opportunity of examining an example, through the kindness of Mr. George Thompson, of Corngreaves Hall, who several times accompanied me through the underground workings, and gave me every information both there and in his office.

It occurs at the Baremoor colliery, about three miles south of Dudley. The Thick coal is worked all round the neighbourhood with its usual thickness and characters, and at a depth varying from 350 feet to 600 feet below the surface. A little above it is the usual Thick coal rock or sandstone, rather thicker, perhaps, than it is generally found in other parts of the coal-field. The following section,* from the Red Lion colliery, east of Baremoor, represents very closely the usual section found in all the pits about. (See Vertical Sections, sheet 18, No. 22.)

	FT.	IN.
1. Upper measures	448	4
2. Two-foot coal	2	3
3. Batt and coal mixed	3	0
4. Brooch coal	2	6
5. Brooch-stone measures	4	10
6. Herring coal	1	6
7. Pins and Pennyearth	17	2
8. Cannel coal	0	9
9. Brown clunch	3	6
10. Thick coal rock, composed of rock binds (argillaceous sandstone) and peldon (hard flinty stone)	106	2
11. Cat-heath (catch-earth)	1	6
12. Black batt	3	4
13. Thick coal and partings	31	0
Carried forward	625	10

* Communicated by Charles Small, ground bailiff, and given now instead of the Old Baremoor or Corngreaves sections, which have been already published in Murchison's Silurian System.

		FT.	IN.
	Brought forward	625	10
14.	Black batt	2	0
15.	Gubbin ironstone measures	10	6
16.	Heathen coal	3	5
17.	Parting	2	0
18.	Second Heathen coal	3	3
19.	Table batt	0	10
20.	White rock and peldon	15	9
21.	White ironstone measures	5	4
22.	Cake ironstone measures	3	0
		671	11

Now if with that section we contrast the following one, found in sinking the new Baremoor pit, we shall at once see the whole amount of the change :—

		FT.	IN.
*7.	To the bottom of the Pins and Pennyearth	280	4
8 & 9.	Heath measures	15	0
10.	Thick coal rock, composed of rock binds and sandy rock	107	0
11.	Cat heath	2	0
12.	Black batt	3	0
13.	Top part of Thick coal	9	0
	Black batt	0	8
	Sandy rock, mixed with clunch	42	0
	Rock binds	44	8
15?	Black batt	0	4
16.	Heathen coal	2	10
17.	Black batt and fire-clay	5	10
	Brown rock	0	10
	Black batt	1	0
18.	Second Heathen coal	3	2
19.	Black batt	1	4
20.	Soft brown parting	0	3
	Peldon and rock mixed	4	0
	Strong white ground	13	4
21.	White stone measures	6	6
		533	1

* I begin with the same numbers as the last section, for the sake of easy reference.

Here we find that in this shaft all the measures were regular until they came down into the Thick coal, which, however, they passed through in about 9 feet, and came into sandstone. This 9-foot coal was then worked, and it was said to thin out in every direction by the gradual bending down of its roof, till it was no longer worth following. The shaft having been continued into the Whitestone measures without finding any more Thick coal, and the two Heathen coals having been found lying regularly below, they then proceeded to drive gate-roads (or galleries) from the surrounding excavations in the undiminished Thick coal towards this new Baremoor shaft. In so doing they discovered the nature of the mass of interposed sandstone; and in the year 1849 they had already worked round three sides of it, and thus partially proved its extent.* They found it to be an oval cake of sandstone, the major axis of which ran nearly due north and south. It was 13 chains or 286 yards wide, and it had been already traced north and south through a space of about 400 yards, without its northern extremity having been reached. In driving a gate-road towards it in the lowest part of the thick coal, it was found that at the height of about 10 feet from the bottom of "the benches," sandstone came in, and formed the roof of the coal; and from that point the sandstone gradually descended, and cut out bed after bed of coal until it reached the bottom of the benches, and some portion of it even descended below the Thick coal, and cut out the upper Heathen coal. When I first visited this gate-road, it was supposed that this sandstone had cut out the whole, not only of the lower part, but also of the upper part of the Thick coal; and the ground bailiff and colliers assured Mr. Thompson that they had bored upwards for several yards, and found nothing but "rock." This, on the subsequent extension of the workings, was proved to be merely one of those falsehoods that these men so frequently assert to save themselves a little trouble. In 1851 the upper part of the Thick coal was found to extend some distance over the extreme point of the interposed sandstone, and there is very little doubt that the 9-foot coal passed through in the New Baremoor shaft, instead of thinning out in every direction, really thickens gradually towards the upper part of the Thick coal around it. What makes this more probable is, that in working from the Thick coal around, towards the shaft, the coal became hard and intractable, making it more difficult to get. It is probable that for this reason the ground bailiff or butty collier, at that time in charge, declared it thinned out, and was not worth following.

This mass of interposed sandstone was very fine-grained, rather soft, slightly argillaceous, of a light, greenish white colour; not at all differing from the usual argillaceous sandstones of the neighbourhood, which pass under the name of "rock" or "rock binds." It was not only interstratified with the coal *en masse*, but at or near the junction of the two they each

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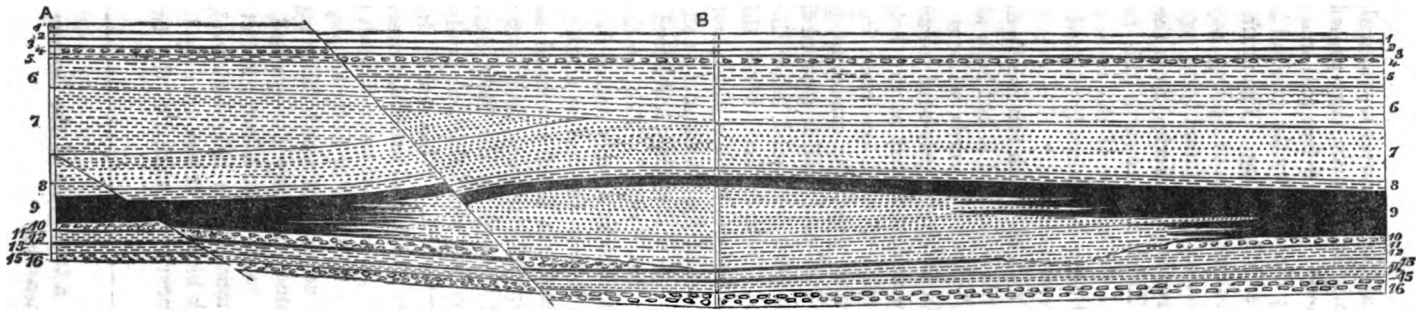
* See figure No. 4, a section on a true scale of the bottom part of the Baremoor shaft, and the adjacent measures.

Fig. 4.



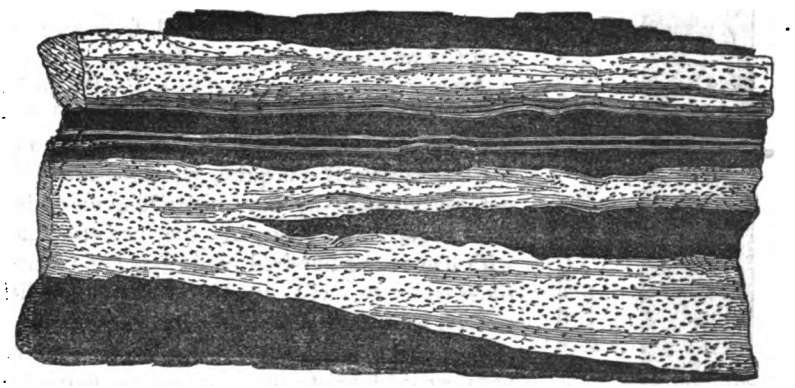
Scale, 1 inch = 133 feet.

A The Old Baremoor shaft.
B The New Baremoor shaft.

1. The Twofoot coal.
2. The Broach coal.
3. The Herring coal.
4. The Broach binds ironstones.
5. Heath measures.
6. Rock binds, argillaceous sandstone.
7. Rock, sandstone.
8. Cat-heath.
9. The Thick coal.
10. The Grains and Gubbin ironstone.
11. The first Heathen coal.
12. Black batt and fire-clay.
13. Second Heathen coal.
14. Batt and soft ground.
15. Rock, sandstone.
16. Cake and white ironstones.

split up into many beds, that interlaced with the utmost regularity. Beds of sandstone, 2 or 3 feet thick, extended many yards into the coal, gradually thinning out and splitting up, so that hand specimens could be procured of alternations of bright coal and pale sandstone, each little bed being not more than one tenth of an inch in thickness. Similarly did small beds and thin laminæ of coal stretch into the mass of the sandstone; a few separate masses also, a foot or so in thickness, sometimes occurring suddenly, not as detached fragments, but as little independent beds in the sandstone. Of the alternation and interstratification of the two materials the following cut (Fig. 5) will give a good idea:—

Fig. 5.



This figure is taken from a hand specimen, and is three fourths the natural size. If it were supposed to be indefinitely enlarged till each bed of coal was 2 or 3 feet in thickness, it would do equally well for a representation of the interlacing of the larger beds. It must be borne in mind that even the minute seams of coal in the above-drawn hand specimen were not mere carbonaceous matter, but were perfectly bright, good coal; and that little or no difference was perceived in the quality of the coals interstratified with the rock fault, and that of the same beds in the unaffected coal around it.

It is clear from the above facts that this is not a case of any kind of denudation of the coal subsequently to its formation, but that whatever cause produced this mass of interposed sandstone was acting *during* the time of the formation of the coal. We will, however, defer the consideration of the theoretical inference to be deduced from these cases to a future page.

The second peculiarity of structure in the Thick coal is that which forms those irregularities, called "horse's backs," "rolls," "swells," "pack-saddle faults," &c. These are caused by a rise of the floor of a coal up towards the roof, in such a manner as to form a long arched ridge running through the coal, sometimes for a very considerable distance. I examined one of

Fig. 6.—Section of a "swell" in the Baremoor colliery.

these in the Baremoor colliery, when visiting it with Mr. Thompson. The black batt, containing nodules of ironstone, which usually lies below the coal, seemed to thicken upwards very gradually, and the three lower coals ended against it with a distinctly rounded outline, and without any mark or sign of disturbance, either cotemporary or at a subsequent period. So gradual was the rise of the lower batt, that at one part of the gate-road it required 18 feet of horizontal distance to rise 2 feet 9 inches vertically. In other words, the slope was not so much as 1 in 6 (= 10°).

Fig. 6 is a sketch of the swell, from a rough drawing and measurement on the spot.

After continuing for a few feet in the Patchells, the crest of the swell gradually descended, letting in the lower coals again, the two sides of it being nearly, if not quite, symmetrical. I do not know what was the longitudinal extension of this particular ridge, but they are often met with one or two hundred yards long; and sometimes one or two will run close together, parallel to each other, for that distance.

It is, of course, possible that they may have been caused by disturbance anterior to or cotemporary with the formation of the lower part of Thick coal. It is, however, much more likely that they were merely long ridge-like accumulations of mud or sand piled up in the water in which the measure forming the floor of the coal was deposited. Theoretically, they are important as showing that whatever was the process of the formation of coal, it was in this case necessarily formed in a strictly horizontal position. The lowest bed of the Thick coal (see figure No. 6) ended against the very gentle slope of the swell, and no bed was formed over it until a sufficient accumulation of coal had taken place around it to make a floor level with its crest. The minute partings of shale or earth between the different beds of coal in the Baremoor colliery sensibly thickened as they approached the swell and coalesced with it.

In a practical point of view these swells are worthy of study, inasmuch as they often dimi-

nish or destroy the value of a tract of coal. They very frequently occur, I believe, in all coal-fields, but it is not always that they can be so well examined and understood as in the Thick coal of Staffordshire. They are commonly spoken of by the colliers as faults, a term likely to lead all concerned into great errors, and which, in a case within my own experience, was the origin of a dispute between two gentlemen in South Staffordshire involving considerable legal expenses.*

C. The Beds below the Thick Coal.—In describing the beds above the Thick coal our materials were principally derived from the southern portion of the field. For the description of the coal itself, we depended mainly on the central portion. For the first seven of the following measures, we shall still derive much information from the southern and central portions of the district, but after that our attention will be principally fixed on a district north of the centre, on the country, namely, between Walsall, Bilston, Wolverhampton, and Bloxwich.

I will first give a list of the principal beds, with their variations in thickness stated in feet.

BEDS BELOW THE THICK COAL.

	Thickness in feet.
1. Pouncill batt, Blackery, and Whitery	2 to 8
2. Gubbin ironstone measures, or little gubbin	2 to 8
3. Table batt	2 to 4
4. Intermediate measures	0 to 24
5. Heathen and Rubble coals	5 to 43
6. Intermediate measures	10 to 33
7. New mine ironstone, or White ironstone	2 to 10
8. Intermediate measures containing the Pennystone (ironstone)	10 to 25
9. Sulphur coal	2 to 9
10. Intermediate measures	2 to 99
11. New mine coal †	2 to 11
12. Intermediate measures	2 to 40
13. Fire-clay coal	1 to 14

* The theoretical and practical importance of these "swells" will be farther noticed hereafter (see pp. 308. 322).

† In the northern part of the district the New mine coal splits up and lets in 45 or 50 feet of other measures between its top and bottom beds.

Beds below the Thick coal—*continued.*

	Thickness in feet.
14. Intermediate measures, including the Poor robin and White ironstone measures	8 to 44
15. Bottom coal *	3 to 12
16. Intermediate measures	5 to 30
17. Gubbin and balls ironstone	0 to 10
18. Intermediate measures, including the Singing coal, or Mealy greys coal	40 to 85
19. Blue flats ironstone, together with the Silver threads ironstone, and Diamonds ironstone	0 to 40.
20. Lowest measures, probably never exceeding	0 to 50.

1. Pouncill batt, Blackery, and Whitery.—Immediately under the Thick coal is almost invariably a bed 1 or 2 feet thick of "black batt," dark bituminous shale, which, in the districts immediately east and west of Dudley is called the "Pouncill batt." Under that is from 1 to 3 or 4 feet of dark "ground" or clunch, called "Blackery." This in the central and southern parts of the fields often contains small nodules of ironstone, called the "Grains ironstone." Under that is 1 or 2 or 3 feet of a light coloured ground or clunch, containing also in some cases ironstone, called the "Whitery ironstone." The three beds together never exceed 8 feet in thickness; they are rarely all present at once, the batt seeming the most constant, but they are sometimes altogether wanting, and the Thick coal rests on the measures containing the Gubbin ironstone. In one instance, namely, at Tipton Green, their place is taken by 6 feet of grey rock.

2. The Gubbin or Little gubbin ironstone.—This seems to be one of the most constant beds in the whole of the district. It generally contains ironstone of good quality, and has been greatly worked. The measures usually consist of dark clunch, containing isolated ironstone nodules in one, two, or three bands. Between Bilston and Wolverhampton the measures are from 2 to 4 feet thick, but around Dudley they are generally 6 feet, and sometimes 7, 8, or 9. The following detailed

* Like the New mine coal, the Bottom coal splits up towards the north and lets in 48 feet of other measures between its top and bottom beds.

section occurs at Upper Gornal clay-works,* and will give a good idea of the structure of these measures :—

	FT.	IN.
Ironstone	0	6
Dark clunch	2	0
Ironstone (cannock)	0	6
Dark clunch	2	0
Ironstone rubble	0	3
Black batt	0	6
	5	9

In some parts around Dudley the ironstone of these measures is called "Blackstone" to distinguish it from the "Whitestone," hereafter to be described.

3. Table batt.—This is a very compact, black, bituminous shale, splitting into large slabs, which when first exposed look firm, but soon crumble to pieces. It is found throughout the southern district with a thickness varying from 2 to 4 feet, except in the neighbourhood of Corngreaves, and thence towards Stourbridge and Kingswinford, where I find no mention made of it, and around Corbyns Hall it is only 1 foot thick. Sometimes it has associated with it a little coal and ironstone, as in the section at Claycroft, near Dudley, which will be useful for comparison with sections farther north ;—

	FT.	IN.
Sharp batt	1	6
Rubble stone	0	5
Little coal	0	6
Brown stone	0	5
Table batt	2	6
	5	4

4. Measures between the Table batt and the Heathen coal.—These are wholly confined to the district between Walsall and Wolverhampton. We have seen that in the south-western angle of the coal-field the last measure is wanting, and there the Gubbin ironstone measures rest directly on the Heathen coal.

* Communicated by Mr. Kenyon Blackwell, to whom I must return thanks for much valuable information.

Proceeding in every direction from this part, the Table batt comes in between them, at first only a few inches thick, but gradually swelling to 4 feet. Still in the district around Dudley there is nothing else to be found between the Gubbin and the Heathen coal; but, as we approach Bradley, we get eventually about 10 feet of fire-clay and clunch, and farther north we find a pretty regular thickness of from 18 to 24 feet (or 6 to 8 yards) of clunch, binds, or other argillaceous material, commonly of a white colour, interposed between the black table batt and the heathen coal. Sometimes a "black ring"*, or a small coal 6 or 8 inches thick makes its appearance in the upper part of these measures, and in the lower part of them there are sometimes ironstone nodules, which are called either Lambstone † or Heathen coal stone.

5. Heathen ‡ and Rubble coals.—I take these two coals and their intermediate beds together, because I believe that the Rubble coal of the northern part of the district is the second or Lower Heathen of the southern part.

The Heathen or upper Heathen coal is a very well marked bed over the whole of the district we are now engaged with; it varies from 1½ to 4 feet in thickness; its usual thickness being about 3 feet. In the district around Corngreaves, Cradley, and south of Brierly Hill there is always mentioned a second or lower Heathen coal, about 2 feet thick, and from 10 to 20 feet below the first or upper Heathen coal. The beds between the two thicken to the south, and at Mr. King's pits at Netherend are 43 feet thick, chiefly sandstones: they thin out to the north,

* A "black ring" when mentioned in a pit section means an impure coaly bed, sometimes called "smut," &c.; it forms a black ring round the shaft, whence its name.

† "Lambstone," I am inclined to suppose to be a corruption of "loam stone;" or it is perhaps another form of the same word, and ought to be written "lam."

‡ This is now the customary orthography of this word in the district. I have, however, seen it written "eathen." The presence or absence of the aspirate is of no account in the matter, as most of the colliers would speak of "a hegg." I believe, therefore, that this term is a corruption of "earthen" as in the case of the "broad heath," &c., mentioned before. Probably the coal when it was first got had an earthy quality or appearance.

and about Corbyns Hall, Shut End, and Kingswinford they first of all thin to 1 foot, and then disappear altogether, the two Heathen coals then being considered one coal, and having a thickness of from 5 to 7 feet. Just on either side of Dudley there appears to be neither lower Heathen nor Rubble coal, but from Tipton northwards around Bilston and thence to Wolverhampton, there is always a Rubble coal varying in thickness from 2 to 4 feet, and in depth below the Heathen, from 7 to 24 feet. The interposed materials contain always clunch and other argillaceous matters, and often some sandstone, which occasionally thickens out, and causes the variations in thickness between the two coals. I believe, therefore, that what is called Rubble coal in the district north of Dudley is the same bed with the Lower Heathen coal of the district south-west of Dudley.

6. Measures between the Heathen and Rubble coals and the New mine ironstone.—These beds in the great majority of instances, wherever they are known, are composed of rock, peldon, and rock binds; that is to say, some variety of sandstone. Sometimes, however, they are said to consist more or less of binds, clunch, or clod, and in a few instances to be entirely composed of those argillaceous materials. Their thickness varies from 10 feet to upwards of 30 feet, the average and by far the most usual thickness being between 15 feet and 20 feet. In some cases, as at Baremoor in the Corngreaves district, they contain ironstone, there called ballstone, as also at Coseley, Gornal, and in the Chillington field, in which latter place there are two courses of ironstone called bindstone.

7. New mine ironstone, or White ironstone.—This is perhaps the most widely-diffused bed of ironstone in the whole district, as it occurs and is worked from Bentley near Walsall on the north to the Hawn near Halesowen on the south. The measures consist almost invariably of clunch, though sometimes they are called clod, or binds; they are always, therefore, of some form of clay; they contain from two to four bands or courses of ironstone, each of which varies from an inch to a foot in thickness. The whole measure is generally 4 feet or 5 feet in thickness, sometimes as little as 2 feet, sometimes, but very rarely, as much as 10 feet.

The following are some details of this measure from different parts of the field :—

Northern part of Bentley estate.

	FT.	IN.
Ironstone	0	3
Clunch	0	7
Ironstone	0	4
Clunch	3	3
Ironstone	0	4
	4	9

Chillington, near Wolverhampton.

	FT.	IN.
Top ironstone	0	3
Clunch	3	3
Bottom ironstone	1	6
	5	0

Highfields, near Bilston.

	FT.	IN.
Ironstone	0	3
Clunch	1	10
Ironstone	0	3
Clunch	1	10
Ironstone	0	6
	4	8

Foxyards, near Dudley.

	FT.	IN.
Ironstone	0	5
Clunch	1	6
Ironstone	0	1
Clunch	1	3
Ironstone	0	3
	3	6

Gornal Clayworks.

	FT.	IN.
White clunch	1	6
Ironstone	0	3
White clunch	2	0
Dark clunch	1	0
Ironstone	0	3
	5	0

Corbyns Hall.

	FT.	IN.
Top ironstone	0	9
Clunch	5	6
Bottom stone	1	0
	7	3

Dudley Woodside.

	FT.	IN.
Ironstone	0	2½
Clunch, &c.	4	0
Ironstone	0	3½
	4	6

Around Dudley and to the south-west of it, as also east as far as Oldbury, on the one side, and north to Ettingshall-lane on the other, the most usual name for this measure is White ironstone. Within these limits it is almost the lowest bed from which ironstone is gotten, and is that on which of late

years the principal dependence has been placed. To the north-west, around Wednesbury and Bilston, and between Wolverhampton and Walsall, this measure is invariably called New mine stone, and in that district it is one of the uppermost ironstone measures, much richer and more important beds being there found below it.

8. Measures between the New mine ironstone and the Sulphur coal, containing the Pennystone.—These beds are almost invariably dark clunch. They are called sometimes black clod and black ground. They contain sometimes throughout their mass, sometimes only in the lower portion of it, flat roundish nodules of ironstone, generally of a dark colour, and sometimes black, so as to be distinguishable from the New mine Whitestone above them both in form and colour. The ironstone is sometimes called Blue ironstone, or the Cake ironstone,* as well as Pennystone. South and west of Dudley they rarely contain ironstone, and the whole mass scarcely ever exceeds 5 feet in thickness, being frequently altogether absent, the only exception I know being at the Graveyards near Lower Gornal, where they are described as "Pennystone measure, 18 feet." In the centre of the field between Dudley and Wednesbury ironstone is likewise often absent, as at Tipton Moat colliery, where we have only "dark ground 20 feet." South of that, however, towards Oldbury, ironstone is got from these beds under the name of Cakes or Bluestone; and northwards between Wolverhampton and Walsall, the Pennystone measures are mentioned in nearly all the sections, with a variable thickness of from 10 feet to 25 feet; sometimes generally as occupying all the space between the New mine stone and Sulphur coals, sometimes, as at Ettingshall Lodge colliery, in the following form:—

	FT.	IN.
New mine stone, in two measures - -	3	3
Dark clunch - - - -	9	0
Pennystone measures - - - -	6	0
Sulphur coal - - - -	2	6

* There is a Cake ironstone worked immediately under the Whitestone at the pits round Cradley Heath, &c., which may perhaps be the same as the Cakes east of Dudley.

To the palæontologist it will be interesting to know that * marine shells in considerable abundance occur near Oldbury in the lower part of the New mine stone and the upper part of the Pennystone, like those so well known in the neighbouring coal-field of Shropshire. They are, however, confined to a very small district between Oldbury and Portway. In one mass of ironstone *lingulæ* were mingled with the common shells called *unio*, which are so abundant in many of the ironstones; but it appeared that generally where undoubtedly marine shells were present these so-called *uniones* were absent. *Lingulæ* are also found in other parts of the coalfield and in lower measures.

9. Sulphur coal.—This is called as frequently the Stinking coal. It is, I believe, rarely or never used, on account of its impure and sulphureous qualities. It is, however, mentioned in its proper place in nearly every section we have over the whole district from the Hawne, where, with a batt, it is 2 ft. 6 in. thick, up to Bentley and the Brown Hills, where it is generally stated as from 1 foot to 4 feet in thickness. At Coneygree near Dudley it is said to be 6 feet thick; and at Tipton-green the Stinking coal and batt is described as having a thickness of 9 feet. Generally its thickness varies from 2 feet to 4 feet, except around Gorsty Hall and Shut End, where it is often only 2 or 3 inches thick.

10. Beds between the Sulphur and New mine coals.—In the Priestfield colliery between Bilston and Wolverhampton there is in one pit 99 feet of binds and rock in this position, and in all the adjoining collieries there are 70 feet or 80 feet of the same

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* My colleague, Professor Edward Forbes, informs me that these fossils are,—

Productus scabriculus.
Avicula quadrata.
Pecten(?) unnamed.
Lingula mytiloides(?)
Orbicula nitida.
Conularia quadrisulcata.
Fish teeth and *bones* undetermined.
An *echinus* very much broken up, probably *archæocidaris*, but in too fragmentary a state to be exactly determined.

materials, the sandstone predominating and passing under the name of the New mine coal rock, or the Twenty-yard rock. This mass of rock is variably split up with rock-binds and peldon, sometimes with clunch. There is often above it a bed of fire-clay or of clunch a few feet in thickness, supporting the Sulphur coal, but that is frequently absent, and that coal rests directly on the rock. Going north towards Bentley the thickness of these measures diminishes to about 30 feet or 40 feet. Going south from Bilston they are still 70 feet at Highfields, consisting of rock and peldon; but at Deepfields there is only 5 feet of fire-clay and 40 of binds, and at Tipton-green but 15 feet of rock, which at Foxyards seems to altogether die out, and 2½ feet of fire-clay alone to interpose between the Sulphur coal and those below it. These great variations in thickness seem to take place principally in the sandstone, which, for instance, about Coseley is only 15 feet thick, while it is more than 60 feet not half a mile off. North of Darlaston, between the Ranters' chapel and Darlaston Forge, the New mine rock, having gradually thinned out from Bilston to a thickness of 9 feet only, suddenly swells out to 78 feet with such rapidity that it was described to me at first as a "fault," by which the heathen coal and upper measures were thrown up 60 feet or 70 feet.*.

11. New mine coal.—This coal has its normal development in the district between Wolverhampton and Bilston, where it is very regular, and is always 6 or 7 feet in thickness. It is split into two, occasionally, by a thin parting of batt of some 6 or 8 inches. This parting is a little more pronounced at Monmore colliery, north of Willenhall,† where we have the following section:—

	FT.	IN.
Coal	3	9
Batt	1	2
Coal	4	6

* I shall hereafter have occasion to remark on the very vague way in which the term "fault" is used in this district, and the patient and skilful cross examination often necessary to get at its true meaning in the mouth of a collier.

† In this colliery and the neighbourhood is so remarkable an instance of the phenomenon well known to all geologists as "false bedding," or "oblique lamination," that it is worth while describing it. Several small quarries

and about a mile north-east of that, around Bentley, the New mine coal is divided into two by measures which vary from

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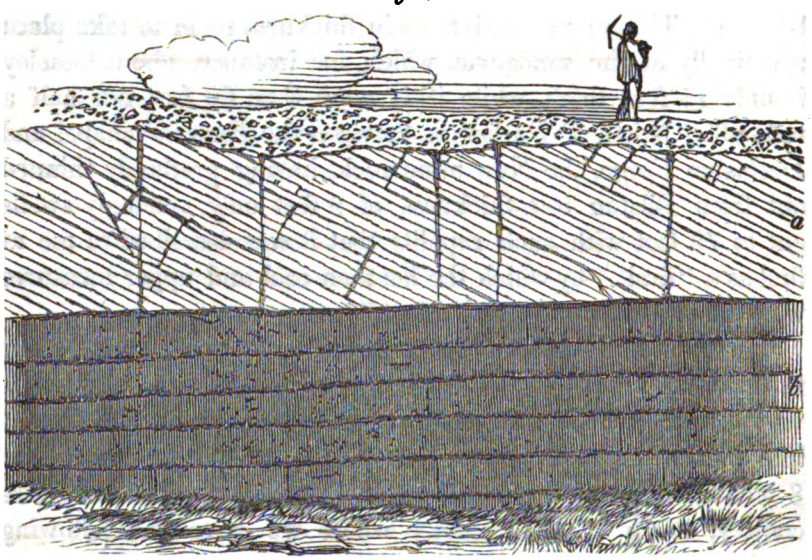
had been opened in some light-coloured sandstone just above the New mine coal, and over a space of nearly a quarter of a mile square, the apparent dip of that sandstone was seen in each quarry to be about 25° to the south-east. The sandstone was fine-grained, with *shaly partings*, often splitting into flags, and the whole of the lines representing stratification inclined at the same amount and in the same direction. As I knew the coal was worked at a very slight depth, I could not understand why it did not crop to the surface, till I came on a larger quarry that explained the puzzle. In this quarry the coal was seen lying as nearly horizontal as possible, with the shaly and flaggy sandstone dipping regularly down on to it at an angle of 25°.—(See figure 7.)

Fig. 7.



a Fine-grained flaggy sandstone. *b* New mine coal.

There was no appearance of any lenticular thickening or thinning of the beds of sandstone, they simply ended against the upper surfaces of the coal, which, when bared, was found to be quite smooth, almost as if polished, but not quite level, forming slight undulations, but with no admixture of any other materials than coal. There were, in some places, about 15 feet of sandstone exposed, and about 8 of coal, the length of the quarry being about 50 yards, throughout which there was no material change in this structure. Like other similar structures in most sandy beds, it shows that the materials must have been brought into their present situation by a pretty rapid current, and that a bank being once produced, the successive accumulations were formed on the slope of it into inclined layers or beds.

30 to 50 feet in thickness, composed partly of clay, but principally of sandstone.

These two coals there lose their name of the New mine, and are called respectively the "Yard coal" and the "Five-foot coal," or in some cases the "Four-foot coal," as shown in the following sections:—

Bentley Heath.

	FT.	IN.	
Yard coal	3	3	
Fire-clay	1	5	40 ft. 7 in.
Rock	0	8	
Clunch	3	0	
Rock	35	6	
Five-foot coal	5	0	
	47	10	

Birch Hills Colliery.

	FT.	IN.	
Yard coal	3	0	
Fire-clay	6	0	
White rock	12	0	46 ft. 6 in.
Peldon	6	0	
Rock binds	22	6	
Four-foot coal	4	0	
	57	6	

Still farther north, about the Brown Hills, we have the following section:—

	FT.		
Stinking or Sulphur coal	1		
Fire-clay	2		
Yard coal rock	30		
Yard coal	3		New mine.
Fire-clay	5	45	
Rock	40		
Bass coal	6		

In this part, though only removed a very few miles from the Willenhall and Bentley district, the terms New mine, &c., are entirely unknown, and the identity of the Yard coal and Bass coal with the New mine quite unsuspected.*

It is remarkable that in these and in most other cases of which I have the details, the two coals, though so widely separated, preserve the aggregate thickness of 6 or 7 feet, sometimes increasing to 8 or 9.

If we proceed from Bilston towards the south, we find that between Bilston and Tipton the New mine coal is either divided and increased, or other small coals come in just below it, and are naturally classed with it; for instance, we have the following sections:—

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* The real fact is, that the colliers of each small district neither know anything, nor care to know anything beyond the bounds of their own small locality, and those of Willenhall and the Brown Hills are thus reciprocally ignorant of each other's terms.

Bilston Meadow.	FT.	IN.
Coal	5	0
Parting	1	3
Coal	4	4
Parting	0	4
Coal	2	0
	12	11

Highfields.	FT.	IN.
Coal	6	0
Parting	2	10
Coal	5	0
	13	10

Lower Bradley.	FT.	IN.
Coal	5	5
Parting	2	1
Coal	2	0
Parting	0	6
Coal	3	0
	13	0

Still further south, however, at Tipton Moat colliery, the New mine coal is only 5 ft. 6 in.; at Tipton Green, 6 ft. 6 in., with a parting; and at Coneygree, near Dudley, 6 ft. Going thence north-west to the Fox-yards, this coal thins to 4 ft.; and at Upper Gornal clay-works it is only 2 ft. thick. Similarly to the east, it is only 1 ft. 6 in. at Messrs. Houghton's Whimsey colliery, near Oldbury.

In a cutting of the South Staffordshire Railway, near the Dudley "Castle foot pottery," the New mine and lower coals were distinctly seen cropping out to the surface, with a thickness of several feet, as also in the cutting on the Oxford, Worcester, and Wolverhampton Railway, on the south-west side of Dudley. Proceeding farther towards the south-west, they appear rapidly to thin out, and finally disappear. A few deep sinkings have been made in this south-western district, in some of which coals, answering, perhaps, to the New mine and those below it, have been passed through, but in so debased a form that it is doubtful whether they are really the same beds, or other little coals occurring here and there near their place.

At the "Graveyard" trial pits, for instance, south of Lower Gornal, below the Sulphur coal, measures were found 22 feet 6 inches thick, consisting partly of clunch and fire-clay, but containing 15 feet of rock; and below them was a coal 1 foot 10 inches thick, believed to be the New mine. At Upper Gornal clay-works there are 19 feet of measures, containing 7 feet of rock between the Sulphur coal, and the 2 feet of coal which represents the New mine. Near Corbyns Hall, in three shafts, there was a coal 1 or 2 feet thick, which was from 45 to 60 feet below the Sulphur coal; the intermediate measures having several beds of rock, amounting altogether to upwards of 20 feet. At Shut End the beds below the Sulphur coal are almost all fire-clay, but 10 or 12 feet of it is described as *gritty*, and at a depth varying from 15 to 30 feet is a small coal 1 foot 6 inches thick. At the Oak Farm colliery there is a coal 1 foot 6 inches thick, 39 feet below the White stone measures. At a deep sinking of Mr. Benja-

min Gibbons's, at the Level colliery* north-east of Brierley Hill, there were found below the Sulphur coal 35 feet of measures, of which 16 were rock; and below these was a small coal 1½ foot thick, which likewise may represent the New mine coal. At the Ley's iron works, north-west of Brierley Hill, Mr. Firmstone sank 280 feet below the Thick coal. Below what is probably the Sulphur coal he met with 22 feet of measures, containing 11 feet of rock, when he came on a "rubble" coal 1 foot 2 inches thick, which may perhaps be the New mine. South of these two places no deep trials were ever made, except in the instance of the Blackheath colliery, south of Rowley Regis; and there nothing was found that could be at all supposed to represent the New mine coal, or any of the beds below it. (See Vertical sections, sheet 17 and 18.)

12. Measures between the New mine and Fire-clay coals.—There is scarcely any group of beds in the whole coal-field which exhibits such rapid and strongly-marked variations as this group. Even in the limited district of the Stow Heath and Priestfield collieries, between Wolverhampton and Bilston, these beds vary from 2 or 3 feet of "binds" to 39 feet of "rock," with a little fire-clay above and below it. Over the whole district in which the two coals occur, the changes in the beds between them are equally marked, even in closely adjacent localities.

For instance, at the Chillington colliery they contain only batt and fire-clay, 4 to 9 feet thick; while a mile south of it, at Cockshutts, the beds are—

	FT.	IN.
Clod	5	0
Rock	26	7
Fire-clay	3	0
	34	7

At Ettingshall Lodge colliery they have—

	FT.	IN.
Batty fire-clay	5	9
Rock and rock-binds	18	6
Dark clunch	3	7
	27	10

While at Ettingshall Lane colliery, one mile south, there are only 2 feet of fire-clay.

* Murchison, Silurian System.

In the central part of the field, south of Bilston, we get the following sections :—

Bradley Lodge.

	FT.	IN.
Fire-clay and batt	4	8
Dark ground	3	0
Fire-clay and ironstone balls	3	9
	11	5

Lower Bradley.

	FT.	IN.
Fire-clay	9	8
Little coal	0	10
Fire-clay	6	0
Rock	3	0
Fire-clay balls, an occasional ironstone	3	0
Dark ground	4	0
	26	6

Around Highfields, Deepfields, and Tipton collieries there are only 2 to 4 feet of fire-clay, clunch, or binds ; but at Coneygree, near Dudley, these beds again swell out to the following section :—

	FT.	IN.
Fire-clay	2	0
Rock-binds	8	0
Rough rock	3	6
Binds mixed with peldon	4	0
Fire-clay balls ironstone	4	0
Hard rock	3	6
Batt	1	2
	26	2

We will leave the attempt to trace these beds south and west of Dudley till after the description of the Fire-clay coal. Going north from the district already described, (north of Willenhall that is,) we find these beds to have a more constant character than elsewhere, always preserving a thickness of more than 20 feet, and consisting of alternations of rock, fire-clay, and clunch, as the three following sections will show :—

Central Part of Bentley Estate.

	FT.	IN.
Batt, fire-clay and binds	8	8
Rock	1	4
Binds	7	4
Rock	0	8
Binds and ironstone	4	0
Coal	0	7
Fire-clay and binds	9	0
	31	7

Dudley Brothers Colliery, between Bloxwich and New Invention.

	FT.	IN.
Batt and fire-clay	6	0
Rock binds	17	10
Black batt	0	6
White rock	1	8
Batt	2	0
White rock	3	0
Black batt	1	7
	32	7

Brown Hills Colliery.

Fire clay	2
Rock	27
	29

13 Fire-clay coal.—We will again take the Stow Heath and Priestfield collieries, between Wolverhampton and Bilston, as the typical locality for the description of this coal. It has there an almost invariable thickness of 9 or 10 feet, with or without a "parting;" and at a distance of 1 to 3 feet below it is another small coal called there "the Little coal." The following is the section of a shaft a little east of Stow Heath Furnace:—

	FT.	IN.	
Fire-clay coal, top	6	0	9 feet.
Parting	1	0	
Fire-clay coal "holers"*	3	0	
Slummy batt	2	6	
Little coal	2	6	

This thickness and arrangement of beds, with some slight variations, seems to prevail through the Chillington, Rough Hills, and Parkfield collieries down to Coseley, and also about Deepfields, Dockmeadow, and Highfields.

In other places, however, both north towards Bentley and south towards Dudley, the Little coal is entirely wanting, and the Fire-clay coal much altered in thickness. In the northern direction we have the following sections:—

Trentham Colliery, between Wednesfield and Willenhall.†

	FT.	IN.
Coal	1	2
Parting	1	0
Coal	2	4
Parting	1	0
Coal	0	10
	6	4

Sandbeds between Willenhall and Bentley.‡

	FT.	IN.
Coal	1	2
Parting	0	9
Coal	2	8
	4	7

Bentley Heath.‡

	FT.	IN.
Coal	2	1
Fire-clay	0	7
Coal	1	2
	3	10

* "Holers" is a term frequently applied to the lowest of a set of coals which are sufficiently close to be "gotten" together. In getting the coal a low wide hole is excavated by the pick some distance into the bottom bed of coal; the upper beds are then cut on each side of this "hole," and, of course, fall into it.

† Communicated by Messrs. Bate. ‡ Communicated by Mr. George.

On the southern side of Stow Heath we get frequent sudden changes even in spots surrounded by places before-mentioned. At Friezeland colliery, for instance, just south of Priestfield, there is only "batt and coal, 2 feet," to represent the Fire-clay coal. At Lower Bradley we have "coal and batt, 5 feet," but at Mr. Addenbrook's colliery at Upper Bradley, there is a little coal above instead of below the Fire-clay coal, as follows:—

	FT.	IN.
Coal	0	6
Black batt	5	0
Fire-clay coal	5	4

Similar to this is a section at Tipton Green, where the only representative of the Fire-clay coal is,—

	FT.	IN.
Coal	0	3
Fire-clay	5	0
Coal and batt	2	6

The section at Tipton Moat is the same, except that the lowest coal is only 10 inches thick. At Gornal clay-works there is simply 2 feet of poor coal; at Darlaston the same; and at Dudley Port, 2 feet 6 inches. At the Foxyards, however, we have the two following sections:—

*The Sinking Pit.**

	FT.	IN.
Little coal	1	6
Fire-clay	1	6
Coal	0	7
Fire-clay	2	5
Coal	2	7
	8	7

Another Pit.†

	FT.	IN.
Coal	2	7
Parting	1	9
Coal	1	4
	5	8

If now we pass into the district south and west of Dudley the same remarks will hold good as to the "Fire-clay" that were used respecting the "New mine coal," but to a still greater extent. There are but five shafts of which I have sections, in which any coal near its place is mentioned. Of these one is the Grave-yard Trial pits,‡ south of Gornal, where below what is supposed to be the New mine coal we get,—

	FT.	IN.
Rock and fire-clay	5	9
Coal (possibly the Fire-clay)	1	8
	7	5

* Communicated from Lord Ward's office, by Mr. R. Smith.

† From Smith's "Miners' Guide."

‡ Lord Ward's office.

Two shafts near Corbyns Hall give below what is there believed to be the New mine coal,—

	FT.	FT.
Fire-clay - - -	10 to	12
Coal - - - -	0 „	1
	—	13

At Shut End we get below the supposed New mine coal the following beds:—

	FT.	IN.
Gritty and strong fire-clay. - -	16	4
Coal and batt - - - -	1	6
Hard white rock - - -	10	4
Coal - - - -	2	8
	30	10

Which (if either) of these may represent the Fire-clay may be reasonably a matter of doubt.

At Mr. Gibbons's deep sinking at the Level near Brierley Hill, there was below the supposed New mine coal,—

	FT.	IN.
Fire-clay - - - -	7	0
Clunch with balls of ironstone - -	4	0
Binds - - - -	2	8
Coal and batt, possibly Fire-clay coal -	1	6
	14	9

At Mr. Firmstone's deep sinking at the Leys, however, not a trace of coal had been met with below that which we have already designated the New mine, although the sinking was continued for upwards of 77 feet.

14. Measures between the "Fire-clay coal" and the "Bottom coal," including the "Poor robin ironstone," and the "Rough Hill White ironstone."*

The total thickness of these beds varies commonly from 20 to 30 feet in the district where they are most worked, namely, between Wolverhampton and Walsall. The upper measure is generally fire-clay or clunch, supporting the Fire-clay coal and varying in thickness from 2 to 10 feet. This, however, is sometimes entirely wanting, and the Fire-clay coal rests directly on a

* I can only refer the origin of the term "Poor robin" to the fantastic imagination of some fanciful collier. The other derives its name from its colour and the locality, the Rough Hills south of Wolverhampton, where it was first worked.

"strong rock" or hard sandstone. This rock sometimes contains so much ironstone either in plates or nodules as to be worth getting, and it is hence called the "getting rock." Beneath this is either more "rock" or else "batt," "clunch," or "binds," several feet in thickness, and then a measure always of argillaceous materials containing either nodules or courses of ironstone, which is the "Poor robin." Immediately beneath this, or sometimes with a few feet of rock, or binds, or clunch interposed, come the Rough Hill White ironstone measures. This ironstone is very local, being only found between Bilston and Wolverhampton in sufficient quantity to be worth working. At Parkfields, south of Wolverhampton, the whole measure is 19 feet 2 inches thick, with 11 bands of ironstone in it, but elsewhere even when it occurs it is rarely more than 2 to 4 feet in thickness.

The following are a few selected sections of this group of beds :—

*Bentley.**

	FT.	IN.
Fire-clay	1	4
Clunch and binds	19	4
Rock	4	0
Binds and clunch	12	2
Clunch and ironstone, probably Poor robin	2	8
Whitestone (iron)	4	11
	44	5

Stow Heath.†

	FT.	IN.
Fire-clay	3	0
Slums	3	0
Getting rock	4	0
Black batt	7	6
Poor robin	2	6
Black batt	9	0
Whitestone	2	3
	31	3

Priestfield.‡

	FT.	IN.
Black clod	10	0
Poor robin	4	0
Light clod	7	0
Whitestone	2	6
	23	6

Ettingshall Lodge.§

	FT.	IN.
Getting rock	4	9
Stratified grey rock	1	4
Batt, inflammable	7	7
Poor robin	3	6
Batt, inflammable	5	0
Whitestone	3	6
	25	8

* Communicated by Mr. George.
† Communicated by Mr. Arthur Sparrow.
‡ Communicated by Mr. W. Ward.
§ Communicated by Mr. Griffith of the Cock-shutts.

*Deepfields.**

	FT.	IN.
Getting rock	5	0
Poor robin	3	3
Whitestone	3	0
Ironstone balls and gubbin	4	9
Fire-clay	10	6
	26	6

Bradley.†

	FT.	IN.
Fire-clay	6	0
Rock	0	7
Ironstone balls	1	6
Rock binds	12	6
Poor robin	4	11
Black batt	3	11
Whitestone	3	9
	33	4

If we proceed, from the district thus characterized, farther south, we find one or both of the ironstones quickly disappear, and the total thickness of the beds to diminish sometimes to only 8 feet. At Highfields, for instance, although there is still ironstone, the beds between the Fire-clay and Bottom coals are only two measures of clunch, with ironstone balls, each 4 feet thick.

Elsewhere we get the following sections :—

Lower Bradley.†

	FT.	IN.
Fire-clay	9	0
Getting rock	9	0
Dark ground	17	6
	35	6

*Coseley.**

	FT.	IN.
Rock	6	6
Ironstone measures	4	6
Binds	5	6
	16	6

Near Cann Lane.‡

	FT.	IN.
Strong rock	28	0
Black batt	3	0
	31	0

Near Darlaston.†

	FT.	IN.
Brown bastard fire-clay	10	9
White rock	0	3
Brown clunch	6	0
	17	0

The Foxyards.§

	FT.	IN.
Fire-clay rock	2	0
Dark rock	3	0
Fire-clay balls (Poor robin?)	3	6
Ironstone (Rough Hills White?)	2	6
	11	0

Tipton Green.‖

	FT.	IN.
Rock	9	5
Rock, with balls of ironstone	1	11
Rock	6	10
	18	2

* From the Miner's Guide. † Communicated by Mr. S. H. Blackwell.
‡ Communicated by Mr. Grogart.
§ Communicated from Lord Ward's office. ‖ Communicated by Mr. Johnson.

15. The Bottom coal.*—In the part of the coal-field near Wolverhampton, this coal has a pretty uniform thickness of about 12 feet, as in the following section given me by Mr. W. Ward, from a pit a little south of Stow-heath furnace :—

	FT.	IN.
† Gainies (inferior coal)	2	0
Top coal	5	0
Parting	1	0
Holers coal	4	0
	12	0

This condition of the Bottom coal extends generally from Wolverhampton to Willenhall, Bilston, and Coseley.

Outside of those limits, however, the variations in the character of the Bottom coal are many and sometimes come in suddenly. Even within those limits we have the following sections :—

Parkfield.‡

	FT.	IN.
Coal	4	9
Parting	0	8
Holers coal	1	0
	6	5

Ettingshalls Lodye near Catchem's Corner.‡

	FT.	IN.
Gainies' bad coal	1	6
Parting batt	0	4
Top coal	5	3
Parting batt	10	0
Holers coal	4	6
	21	7

Dockmeadow, south of Bilston Ironworks.

	FT.	IN.	
Coal	4	6	
Rock	6	0	14 ft.
Rock binds	3	0	
Ironstone balls	1	0	
Rock binds	4	0	
Coal, believed to be Holers	3	0	
	21	6	

* This name, assigned to it at first in one locality, turns out, as is often the case, to be a misnomer, as in other localities there are other coals below it, one of which at least is sometimes worth getting.

† Takes its name, I believe, as the bed by which they first arrive at or gain the coal in sinking a pit.

‡ Communicated by Mr. Griffiths.

These three places lie in a straight line about one mile in length, and running nearly west-north-west and east-south-east.

About a mile south of Bilston, at Highfields and Bradley, the Bottom coal is only 3 or 4 feet thick. At Tipton Moat Colliery it is 9 ft. 6 in., from which 2 ft. 6 in. must be deducted for three "parting batts;" at Tipton Green there is said to be "coal and batt," 11 ft. 9 in.; and at the Foxyards, 9 or 10 feet of coal. Farther south, however, at Coneygree and Dudley Port, the Bottom coal, if it exist at all, is not more than a foot or so in thickness.

At Shaver's End, just north of Dudley, the following was the section in a trial pit of Lord Ward's :—

	FT.	IN.
* Coal	2	0
Parting	0	9
Coal	2	0
Parting	0	7
Coal	0	10
Parting	1	0
Coal	2	0
	9	2

Including 2 ft. 4 in. of partings.

And at Upper Gornal clay works, the following beds represented the bottom coal :—

	FT.	IN.
† Coal	1	6
Parting	0	8
Coal	0	4
Fire-clay	1	2
Coal	2	0
	5	8

Including 1 ft. 10 in. of parting.

A mile and a half south of this latter locality, at the Grave-yards, in what we have spoken of as the south-western part of the coal-field, we get, below the little coal which we have already supposed to be the Fire-clay coal, a set of beds 28 ft. 5 in. in thickness, alternations of fire-clay, rock, clunch, and binds, and containing two "ball ironstone measures," which may perhaps represent the ironstones of the "Poor robin," and "Rough Hill White;" and below these, a coal 2 feet thick, which may probably represent the Bottom coal.

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* Lord Ward's office.
† Mr. J. Kenyon Blackwell.

Similarly at Mr. Gibbon's Level colliery, there was found the following section :—

	FT.	IN.	
1. Coal and batt, supposed Fire-clay	1	6	
2. Fire clay	6	3	20 ft. 11 in.
3. Strong dark clunch, with balls of ironstone	6	5	
4. Strong white rock	4	0	
5. Broad earth, with balls of ironstone	4	3	
6. Coal	1	0	8 ft. 6 in.
7. Black batt	0	5	
8. Fire-clay	5	8	
9. Coal and batt	1	5	
	30	11	

Of which beds 2 to 5 may represent those described in the last section (No. 14), and either 6 or 9, or the group of 6 to 9 inclusive, may represent the "Bottom coal." These are the only localities in this south-west district in which, so far as I am aware, any beds that can be compared with the Bottom coal of the Wolverhampton district have been met with.

We may now return to Willenhall, and trace the Bottom coal towards the north and east, namely, to Bentley, Bloxwich, and the Brown Hills. At the Trentham colliery, near Mumber-lane, the Bottom coal assumed the following form :—

	FT.	IN.	
* Coal	0	11	7 ft. 6 in.
Parting	0	3	
Coal	0	5	
Parting	0	4	
Coal	0	7	
Parting	0	2	
Coal	4	10	
Fire-clay	1	6	21 ft. 6 in.
Clod and stone	10	0	
Rock binds	8	0	
Batt	2	0	
Holers coal	4	6	
	33	6	

At Monmore colliery, half a mile east of this, there was—

	FT.	IN.	
Coal	3	2	
Fire-clay	6	9	32 ft. 9 in.
Rock binds and ironstone	7	8	
Fire-clay	18	4	
Coal, holers	3	3	
	39	2	

* Messrs. Bate.

About Bentley the coals close together again with only a little batt between them, but make a total thickness of not more than 7 or 8 feet. This at the Birch Hills becomes 12 or 14 feet, with only 8 inches of batt; but going north towards Bloxwich the coals again split into two, and become separated at first only by a few feet of fire-clay, but afterwards, north of Goscott, by upwards of 50 feet; and about Pelsall and the Brown Hills they are permanently separated by from 45 to 54 feet of rock, rock-binds, and clod, and always considered as two coals, called Shallow and Deep coals, as in the following section :—

	FT.
Shallow coal - - -	6*
Fire-clay - - -	2
Grit rock, hard - - -	46
Deep coal - - -	5

16. Measures between the Bottom coal and the Gubbin and balls ironstone.—The Bottom coal usually rests on a bed of fire-clay some feet in thickness. In many instances, however, this is wanting, and the coal rests on hard sandstone, the change from one material to the other being sometimes very abrupt. Wherever the Gubbin and balls ironstone exists, it is found at a distance below the Bottom coal varying from 5 feet to 30 feet, the most usual distance being 15 feet or 20 feet. The beds between consist sometimes entirely of fire-clay, binds, clunch, or clod, or other argillaceous materials; sometimes these are variously split up by, and interstratified with rock or rock binds, and occasionally these sandy materials almost entirely replace the others. A little coal a few inches thick sometimes occurs in these beds, and the interposed beds of clunch sometimes contain scattered balls or nodules of ironstone.

17. The Gubbin† and balls ironstone.—This set of beds, as a distinct and recognizable measure, containing ironstone worth

* These two coals have been worked nearly continuously from the Brown Hills to Goscott, where they come together and form what is called the "Four yard coal," and near Ryecroft and Walsall is sometimes called "*the thick coal.*" *It is, however, worked continuously* from that place to Willenhall and Wolverhampton, where it is known as the Bottom coal, as above described.

† This term gubbin, one commonly used in all the midland coal-fields, I must frankly confess I do not understand, either as to its origin or the exact meaning to be given to it. The explanations given me were so various and contradictory that I could arrive at no trustworthy result.

getting, and regularly "gotten," is entirely confined to the district between Wolverhampton, Bilston, and Walsall. The following section at Chillington colliery near Wolverhampton gives its best developed form:—

	FT.	IN.	
Balls of ironstone	0	8	3 ft. 8 in.
Clod	2	6	
Balls of ironstone	0	6	
Dark clod	1	6	
Gubbin ironstone	0	6	1 ft. 9 in.
Clod	1	0	
Gubbin ironstone	0	3	
	6	11	

Measures similar in character, varying from 5 feet to 10 feet, and containing more or less ironstone, sometimes the Balls, sometimes the Gubbin being absent, and sometimes both found wanting, extend all over the district just mentioned. South of Bilston around Bradley they diminish to about 3 feet. At Tipton Moat colliery there is mentioned "binds with ironstone, 8 feet," about the place of the Gubbin and balls, namely, at 16 feet below the Bottom coal, but at Coneygree, Foxyards, Gornal, Shaver's End, and the neighbourhood of Dudley generally, there seems no trace of this measure.

The sole vague and uncertain trace of them in the south-western district is the mention in the Graveyard section of "ironstone balls 6 inches," at a depth of 5 ft. 6 in. below what is believed to be the Bottom coal.

Going north towards Bentley, we get, at the Island, the following section:—

	FT.	IN.
Balls of ironstone	0	8
Clunch	2	0
Ironstone	0	4
Clunch	1	0
	4	0

As the representative of this measure in the central part of the Bentley district, and thence by Birch Hills and Bloxwich, there is only mentioned in the section "gubbin 6 inches."

At one part of the Brown Hills, however, near Clayhanger, Samuel Arblaster found under the Deep coal—

	FT.	IN.
Fireclay and clunch	13	6
Gubbinstone, balls of ironstone in two or three layers, and each 6 or 8 inches thick	3	0

Near Wolverhampton the Gubbin and balls stone is a very well marked and easily recognizable kind of stone. The large nodules are generally septarian, the septa being lined with white spar, crystals of carbonate of lime and carbonate of iron, together with crystals of iron pyrites, and not unfrequently of both galena and zinc blende.

18. Beds between the Gubbin and balls and the Blue flats ironstone, including the "Singing" or "Mealy-greys" coal.

Wherever the Gubbin and balls is mentioned in the sections as a recognizable measure, there is found just below it either a little bed of pure coal 6 or 8 inches thick, or a bed of "slum" (batty coal), which is often 2 or 3 feet thick, and sometimes more. In Cockshutts colliery only is there a thin bed of sandstone between this coaly material and the Gubbin and balls.

At a distance below the Gubbin and balls, which varies from 18 to 50 feet, there occurs a coal 2 to 4 feet in thickness, which is called sometimes the Singing* coal and sometimes the "Mealy-greys"† coal.

In the Wolverhampton district the thickness of the beds between the Gubbin and balls and the Singing or Mealy-greys coal seems never to exceed 24 feet, nor fall below 18 feet, except where a bed of green rock or trap interposes. At Trentham new colliery, north of Willenhall, however, these beds are 35 feet, and towards Bentley, at "the Island," half a mile east of Willenhall, it is 50 feet, as also at the Monmore colliery. Farther north-east, however, about Birch Hills and Bloxwich, the thickness again diminishes to 33 feet or 26 feet, and the Singing coal itself is only 10 inches or 1 foot in thickness.

In the field south of Bilston there is but little mention of this coal, but it appears in a section at Tipton-green,‡ where, at a depth below the Bottom coal of 37 feet (excluding trap) there is "Singing coal 4 feet." If from this we take off a portion to include the Gubbin and balls, &c., the remaining thickness will be very nearly equal to what these beds have near Wolverhampton.

In some parts between Wolverhampton and Bilston I believe the Singing or Mealy-greys coal is now "gotten," and is looked on by the iron-masters as a valuable help to their resources.

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* This name was described to me as arising from the fact, that as they passed through it in some places, the gas could be distinctly heard issuing from its crevices "like the singing of a tea-kettle."

† Where it has this designation, it is said to be of a greyish hue and to be partly friable or "mealy."

‡ Given me by Mr. Johnson of Dudley.

The materials composing the beds just described are generally an alternation of fire-clay, clunch, or binds, with rock or rock-binds, sometimes the argillaceous, sometimes the arenaceous character predominating. In the neighbourhood of Bentley one or two little coals a few inches thick likewise show themselves.

Below the Singing or Mealy-greys coal we get a mass of beds consisting sometimes entirely of fire-clay, more frequently of alternations of fire-clay and rock, varying in thickness from 16 feet to 50 feet, before we reach the Blue flats ironstone. As in the case of the beds above described, these measures are also thickest in the Bentley district, where they contain also one or two little beds of coal, and in their lowest portion some ironstone balls. The alteration in thickness in these beds is sometimes rapid, as in a colliery at Portobello near Wolverhampton, in two pits within 150 yards of each other, the beds, consisting in both of fire-clay and rock, varied from 16 feet to 29 feet in thickness. Elsewhere about Wolverhampton they have a pretty constant thickness between 20 feet and 25 feet.

The two groups of beds, namely, those above and those below the Singing or Mealy-greys coal, while they each vary in thickness in different places, usually vary in such a way as to balance each other and maintain a certain mean aggregate thickness.

The aggregate thickness of the whole beds between the Gubbin and balls, and the Blue flats ironstones is, near Wolverhampton, never more than 53 feet nor less than 40 feet (exclusive of trap); but north and east of Willenhall, around Bentley, and up to Bloxwich, it is never less than 70 feet, and sometimes reaches 85.*

It will be important to bear these facts in mind when we come to describe the trap rocks which have been intruded into these beds.

19. The Blue flats ironstone, together with the Diamonds and Silver threads.—We have now to describe the lowest recog-

* In Samuel Arblaster's pit near the Brown Hills before mentioned, they got some ironstone somewhat resembling the Blue flats at a depth of only 12 feet (white tender rock) below the supposed Gubbin and balls. The identification of the measures, however, is too doubtful for us to found any argument on.

nizable measures in the whole of the South Staffordshire coal-field, those beneath which neither coal nor ironstone have ever been found that were of the least value.

The Blue flats ironstone is confined absolutely as a workable measure to the district between Wolverhampton and Walsall, scarcely going south of Bilston, nor so far north as Bloxwich. It is an easily recognizable ironstone, as it occurs usually in regular bands a few inches thick, which are smoothly jointed, and are but slightly concretionary in structure. When brought to the pit bank the lumps of ironstone look like large rather irregular bricks; they are pale brown at first, but from exposure to the air assume a dull blue or purplish look. This colour, joined to the flat pavement-like form in which they are found below, gives them their name.

The ironstone usually occurs near Wolverhampton in two, three, or four regular bands, interstratified with clunch or clod, as in the following sections:—

*The Cockshutts.**

	FT.	IN.
Clod	4	0
Ironstone	0	4
Clod	2	0
Ironstone	0	2
Clod	3	0
Ironstone	0	3
	9	9

Park Hall.†

	FT.	IN.
Topstone	0	6
Binds, &c.	2	0
Second stone	0	3
Parting	1	3
Third stone	0	4
Ground with chitterstone	4	2
Bottomstone	0	3
	8	11

Chillington.‡

	FT.	IN.
Stone	0	5
Clod	1	0
Stone	0	5
Clod	0	6
Stone	0	2
	2	6

The Blue flats are mentioned with a thickness of about 3 feet at Deepfields and Bradley, and as 5 feet thick at Darlaston; but what proportion of ironstone they contain there I do not know.

In some places near Wolverhampton mention is made of the "Bristol diamonds ironstone," just below the blue flats. It seems there to be very poor and trifling; but as we proceed to the north-east we find around Bentley and Walsall the Diamonds ironstone as rich and important as the Blue flats, and, moreover, the "Silver threads" coming in between them, with much ironstone in bands and cakes in the intervening measures.

* Mr. Griffiths. † Lord Ward's office.

‡ Murchison's Silurian System.

The section here is of a totally different character from that near Wolverhampton, as may be seen by the following examples :—

*Bentley Estate.**

		FT.	IN.	FT.	IN.
Blue flats	Ironstone	0	4		
	Binds	3	0		
	Ironstone	0	1		
	Binds	1	6		
	Ironstone	0	2		
				5	1
	Binds with ironstone nodules			9	8
Silver threads	Ironstone	0	1		
	Binds	1	0		
	Binds with ironstone	3	4		
	Ironstone	0	2		
				4	7
	Binds			6	0
Diamonds	Ironstone	0	3		
	Binds	1	4		
	Ironstone	0	2		
	Binds	1	5		
				3	2
				28	6

Ryecroft, north of Walsall.†

		FT.	IN.	FT.	IN.
Blue flats	Ironstone cake	0	3		
	Blue clod	1	0		
	Ironstone	0	3		
				1	6
	Blue and white clod	3	7		
	Ironstone balls, called grandads	0	8		
	White clod	10	0		
				14	3
Silver threads	Ironstone	0	3		
	White clod	2	8		
	Ironstone	0	4		
	White clod	3	0		
	Ironstone	0	3		
				6	6
	White clod	7	6		
	Balls of ironstone (sometimes)	0	8		
	White clod	7	0		
				15	2
Diamonds	Ironstone	0	3		
	Black clod	2	0		
	Ironstone	0	4		
				2	7
				40	0

* Mr. George. † Mr. Arthur Sparrow.

Going still farther north, again, the ironstones seem to be rapidly dying out and disappearing. At Dudley Brothers colliery, for instance, about half a mile west of Bloxwich, although these measures were still recognizable, they contained so little ironstone as not to be worth working; while around Pelsall they sank at one place 150 feet below the Bottom coal without finding either coal or ironstone, till at that depth they came on a little "lean" ironstone, which was conjectured to represent the Blue flats.

In page 187 is given a table of the beds below the Thick coal, with the minimum and maximum thickness of each, as described in the foregoing pages. If the minima were added together we should only have a thickness of 91 feet for the whole of the beds between the bottom of the Thick coal and the top of the Blue flats. If the maxima were added, on the contrary, we should have a total thickness of 605 feet. The mean of these two numbers is 348. Now it is a remarkable instance of the way in which the frequent variations in the thickness and character of the beds are equalized among themselves, and a certain mean thickness kept, that the mean of 13 sections distributed pretty equally over various parts of the district, gives 320 feet as the actual mean thickness of the beds between the base of the Thick coal and the top of the Blue flats. If, moreover, we arrange these 13 sections in the order of their thicknesses, we shall find that that will very nearly be the order of their latitude, the thinnest section being the most southerly and the thickest the most northerly; the others being nearly regularly arranged between them. I add at the beginning a section still further south, at Foxyards, where it was doubtful whether the ironstone were the Blue flats or not; the probability of its being so having become much greater from the way in which it harmonises with the other sections.

	Thickness between the Thick Coal and Blue Flats in Feet.
1. Foxyards	240
2. Bradley	270
3. Deepfields	274
4. Crabtree piece, near Bilston	290
5. Stowheath	300
6. Friezland	302
7. Stowheath	306
8. Chillington Colliery	312

	Thickness between the Thick Coal and Blue Flats in Feet.
9. Rough Hills	329
10. Priestfield	333
11. Ettingshall Lodge	336
12. Bentley Estate	365
13. Bentley, another shaft	378
14. Bloxwich	395

This exhibits very clearly what has been before alluded to in describing these beds, the gradual thickening of them towards the north, the total section being 150 feet greater at one end than the other.

If we were to take the thickness of the beds from the base of the Thick coal to the base of the Bottom coal, we should get precisely similar results as a whole. As, however, we possess 30 sections, which include the necessary data for the Bottom coal, while we have only 13 for the Blue flats, we should expect to find one or two of them a little out of their place, owing to partial and strictly local thickening or thinning of a few beds simultaneously, while generally these variations in thickness balanced each other. I add this list arranged in order of thickness:—

	FEET.	
*1. The Grave-yards	120	The south-western district.
2. The Level	133	
3. Upper Gornal	133	
4. Foxyards	159	Between Dudley and Wednesbury.
5. Tipton Green	160	
6. Coneygree	167	
7. Tipton Moat	167	
8. Bradley Lodge	176	All between the latitudes of Coseley and Bilston.
9. Ettingshall, near Cann-lane	176	
10. Highfields	194	
11. Highfields	196	
12. Highfields	203	
13. Deepfields	205	
14. Bradley	213	
15. Dockmeadow	216	

* In geographical order the Grave-yards would come between Nos. 2 and 3.

		FEET.	
16.	Priestfield Furnace	225	All on or about the latitude of Bilston.
17.	Bilston Meadow	228	
18.	Priestfield Colliery	229	
19.	Friezland	232	
20.	Crabtree Piece	240	
21.	The Wallbutts	242	
22.	Chillington Colliery	250	All north of Bilston, near Wolverhampton.
23.	Stowheath	253	
24.	Rough Hills	256	
25.	Bentley Heath	263	Still farther north.
26.	Bentley Hall	265	
*27.	Lower Bradley	266	South of Bilston.
†28.	Ettingshall Lodge	270	Due west of Bilston.
29.	Bentley, northern part	276	North of 26.
30.	Bloxwich	291	North of 29.

It follows, from an inspection of this list, that our identification of the Bottom coal in the three sections in the district south and west of Dudley, namely, Nos. 1, 2, and 3, that identification being founded only on the details of the sections, is rendered still more probable, from its harmonizing so well with our general results.

20. The base of the Coal-measures.—It remains now only to investigate the nature and thickness of the beds that lie below the Blue flats, or, where that measure is not present, the lowest beds of the Coal-measures in each locality.

I may premise, that in the cutting of the railway near Trindle Gate, just east of Dudley, the base of the Coal-measures was very well exposed, resting on the Silurian shale, and exhibiting the following facts.

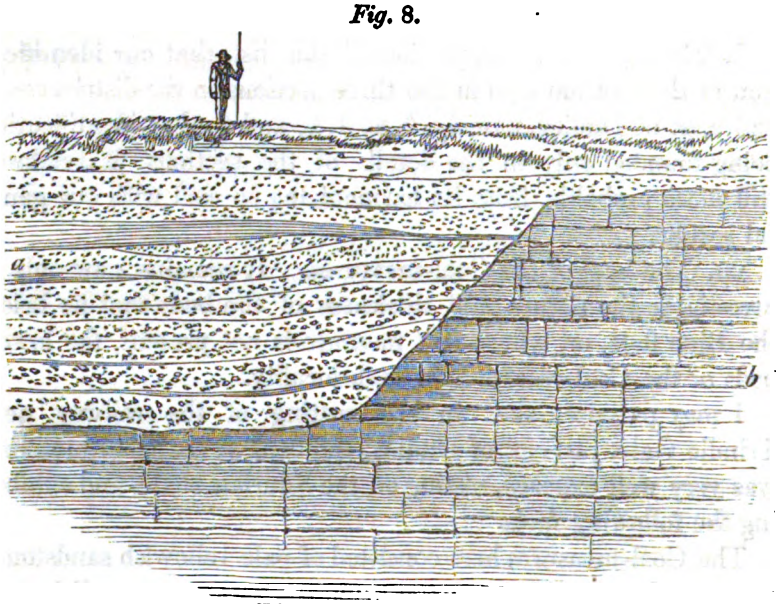
The Coal-measures here consisted of pale yellowish sandstones, many of them argillaceous (rock binds), with some small beds of shale or clay. The Silurian shale was a compact blue shale in thick beds, lying very regularly in a nearly horizontal position. At one part of the section some of the upper beds of the Silurian

* The abnormal position of this section is due to a local thickening of the beds between the Thick and Heathen coals.

† Due to a local increase in the thickness of several of the measures, which is compensated for in the beds below the Bottom coal, as in the Blue flats list this section takes its proper geographical position.

shale ended in a moderately sloped cliff, against which the sandstone of the Coal-measures abutted, while they reposed on the lower beds of shale that continued beneath them. As both groups of beds were nearly horizontal, no unconformability could be perceived between them, except just at the little Silurian cliff. Here the lamination of the sandstones became oblique, trying to conform to the slope of the cliff, and the lower beds of it, both near the cliff, and for some yards back, contained pebbles and many small angular fragments. The pebbles were mostly white crystalline quartz, with some rolled pieces of ironstone. The angular fragments were chiefly Silurian shale and limestone. The cliff was about 20 feet high (see figure 8).

Fig. 8.



a Coal-measures. *b* Silurian shale.

From this very instructive instance we learn generally how, with perfect apparent local conformability, there may be still on the large scale a very great amount of unconformability between two formations, and in this special case we see the nature of the relation between the Coal-measures and Silurian rocks of the South Staffordshire coal-field; that the Silurian rocks were greatly denuded and worn away, and cliffs and hollows formed in them,

on, against, and over which the Coal-measures were deposited, both lying in a nearly horizontal position.

In the district south and west of Dudley there has been no pit sunk from any of the known beds of the Coal-measures down to the Silurian, unless they reached that formation in the Blackheath colliery, south of Rowley Regis (see Vertical section, sheet 18, No. 26.) In that abortive search for valuable coal or ironstone, they reached, at 570 feet from the surface, the representative of the Thick coal in a debased and worthless form, and they sank to a depth of 121 feet below it, meeting with only a few trifling beds of coal or ironstone. At a depth of 661 feet from the surface, and 81 feet below the Thick coal, they met what is described as "red parting and limestone, 1 inch," and below that they found thick and regular beds of "rock binds," separated by inch partings of white clay. Now if the sinkers had never before worked in the Silurian rocks they might easily have described those as "rock binds," and they bored through *precisely similar materials* for 300 feet below the bottom of the shaft. This statement makes it very probable that the last 340 feet out of the 1,001 feet passed through altogether, consisted of Silurian shale, since it is totally contrary to the nature of the South Staffordshire Coal-measures to maintain one lithological character through so great a thickness. If these rock binds were Silurian shale, then there was only 81 feet of Coal-measures between it and the Thick coal in that locality.

The nearest deep sinking to this that I am aware of is the one at the Level colliery north-east of Brierley Hill, made by Mr. Benjamin Gibbons, and quoted by Sir R. Murchison in his Silurian System, p. 478. Of this pit we have already investigated the details, and endeavoured to identify the lower coals. The following abstract will give us all further necessary information about it:—

	FT.
To the bottom of the Thick coal - - - -	240
To ditto of 2d Heathen ditto - - -	18
To ditto of Stinking ditto - - -	34
To ditto of New mine (?) ditto - - -	37
To ditto of Fireclay (?) ditto - - -	15
To ditto of Bottom ditto - - - -	29
To ditto of (small coal and batt 8 in.) - -	19
Alternations of "rock," fireclay, clunch, and binds, varying from 2 feet to 10 feet each - - - -	109
Dark gritty rock, with conglomerate - -	26
Light blue clunch - - - - -	3
Below which they bored, in *red clunch* - - -	60
	590

Making a total of 217 feet below the Bottom coal, or 350 feet below the Thick coal, without meeting with anything that appears like Silurian rocks.

At the Leys ironworks, north-west of Brierley Hill, Mr. Firmstone sank a pit, as follows :—

	FT.
To the bottom of the Thick coal - - - -	492
To ditto of Heathen ditto - - -	9
To ditto of Stinking ditto - - - -	10
To ditto of New mine (?) - - - -	24
Beds of fireclay, rock, binds, red and grey clod, and *red rock*, 1 foot to 7 feet each - - - -	39
Red sandstone grit full of pebbles - - -	38
	612

Making a total of 120 feet below the Thick coal; having reached which depth the water burst in on them with such force and rapidity as to oblige them to abandon the sinking.

It is singular that in each of these pits, although at different depths, the lowest beds were red, clunch in one case, (which might be marl,) and sandstone in the other. One might speculate on some beds belonging to the Old red sandstone having come in, were it not that many of the true Coal-measures, both above and below the Thick coal, contain much red and mottled marl and clunch.

At Corbyns Hall Mr. Gibbons sank 172 feet below the Thick coal, the bottom beds being alternations of clunch and rock binds, when a quantity of *salt water* rushed in with such force as nearly to drown the mines.

At Shut End mines Mr. Foster sank 111 feet below the Thick coal, passing 16 feet below the representative of the Fireclay coal, and found much of the water in the lower measures very salt.

The following is a complete abstract of the Grave-yard Trial pits, south of Lower Gornal :—

	FT.
To bottom of Thick coal - - -	43
„ „ Heathen do. - - -	15
„ „ Sulphur do. - - -	43
„ „ New mine do. - -	24
„ „ Fireclay - - - -	8
„ „ Bottom do. - - -	40
To bottom of another little coal passing through many beds of rock, &c. -	112
Several beds of rock - - - -	21
	306

Making a total of 133 below the Bottom coal, or 263 feet below the Thick coal, without attaining the base of the true Coal-measures.

For ascertaining the exact thickness of Coal-measures between any known bed and the top of the Silurian formation in any part of the field, I have but scanty data in any pit sections. Even where it is certain, or highly probable that the sinking was continued down into the Silurian rocks, we are often left to guess at the place of the exact boundary between the two formations, since the miners are but little apt to observe any distinction between the grey shales of the coal-measures and the shales of the Silurian series, Where the latter also are at all hard, or slightly arenaceous, the miners are likely to call them "rock binds," and we are thus liable to class them as Coal-measures. Mention, too, is sometimes made in the sections of a "blue rock;" now, whenever I have seen any beds thus described, I have always found them a compact slightly arenaceous clay rock, so greatly indurated as to form a hard tough stone: and, in sinking a shaft, the Silurian shale of this neighbourhood would be likely often to have these characters, and thus be called by the miners "blue rock." Whenever there is a white or strong brown rock mentioned, I should always consider it as part of the Coal-measures, because I have never seen or heard of any sandstones of that colour in the Silurian shales of this district; and if it were limestone rock, they would almost certainly have described it as such.

With these remarks I now lay before the reader the following ten extracts from pit sections, beginning at the most southerly, and proceeding to the north and east:—

1. *Shaver's End, just north of Dudley.*

	FT.	IN.	
Bottom coal - -	9	2	
Rock and clunch -	39	0	68 ft.
Ironstone measure may=Blue flats	7	0	
Fireclay, rock, and pebbly rock -	22	0	
Blue clunch - -	4	0	
Bavin and limestone	72	0	
	153	2	

2. *Dudley Port, Bagnall's Limestone Pit.*

	FT.	IN.
Bottom (?) coal -	1	6
Fireclay, black ground, rock binds, and rock	60	0
Bavin (Silurian shale) - -	69	0
Limestone - -	27	0
Limestone - -	24	0
	181	6

3. *Tipton Green.*

	FT.	IN.	
Bottom coal	11	9	
Fireclay, rock, &c.	37	0	71 ft.
Singing coal	4	0	
White rock and pebbles	30	0	
Blue binds	130	0	
	212	9	

4. *Foxyards.*

	FT.	IN.	
Bottom coal	9	0	
Fireclay, black ground and rock	80	0	92 ft.
Ironstone (Blue flats?)	4	6	
Strong pebbly light coloured rock	7	6	
Strong blue rock	36	0	
	137	0	

5. *Tipton-moat.*

	FT.	IN.
Bottom coal	9	6
Fire-clay, black ground, binds and ironstone, batt and coal, white rock, &c.	71	0
Blue rock and binds	112	6
Binds	17	0
Stone and binds	172	0
	382	0

6. *Deepfields.*

	FT.	IN.	
Bottom coal	12	0	
Rock, clunch, and rock binds	69	0	71 ft. 6 in.
Blue flats	2	6	
Blue rocky clunch	150	0	
Limestone	50	0	
	263	6	

7. *Parkfield, near Wolverhampton.*

	FT.	IN.	
Bottom coal	11	2	
Various coal measures	68	0	133 ft. 6 in.
Blue flats	10	9	
Diamond clod	2	3	
Strong white rock	22	6	
Dark slaty ground	30	0	
Limestone bavin			
	144	8	

8. *Chillington Colliery, near Wolverhampton.*

	FT.	IN.	
Bottom coal	12	1	
Various coal measures	89	0	91 ft. 6 in.
Blue flats	2	6	
Measures undescribed	240	0	
Limestone clunch, with small bands of limestone	210	0	
	553	7	

9. *Bentley Limestone Pit.*

	FT.	IN.	
Bottom coal	8	8	
Various coal-measures	89	0	146 ft.
Blue flats, Silver threads, and Diamonds	28	0	
Binds, fire-clay, and rock	29	0	
Binds and parting, Silurian	117	0	
Binds with thin limestones	97	0	
Little limestone	12	0	
Shales with limestone	118	0	
Thick limestone	33	9	
Shales with limestone	18	0	
	550	5	

10. *Ryecroft.*

	FT.	IN.
Blue flats, Silver threads, and Diamonds	41	6
Rough rock	6	0
Limestone clunch, binds, and partings	183	0
Little limestone	12	0
Limestone clunch, with hard limestone balls	120	0
Thick limestone	36	0
	398	6

In the first six of these sections there is a remarkable agreement in the total thickness of Coal-measures below the Bottom coal, supposing that in each case the "blue binds" or "blue rock," from its colour and its preserving a uniformity of structure through so much greater thickness than the Coal-measures usually do, be the Silurian shale. At Parkfield (No. 7), the beds below the Bottom coal are thicker than elsewhere, in consequence of the extra thickness in those between the Blue flats and the Silurian shale. At Chillington (No. 8), we have no means of ascertaining this point, or of saying anything more than that they were in the Silurian shale when they got down 240 feet below the Blue flats.

At Bentley, the Coal-measure beds below the Bottom coal have thickened to 146 feet, with 30 feet below the Blue flats group, while at Ryecroft there is only 6 feet of Coal-measures between that group and the top of the Silurian shale.

In all cases, the lowest beds of Coal-measures, where ascertainable, were found to be sandstone, generally containing pebbles.

We have now discussed the details of the physical structure of the Coal-measures in the main part of the South Staffordshire coal-field; it remains for us to examine the other portions of the field. As the workings in those parts we are now about to investigate are few and far between, we shall no longer be able

to trace the beds with anything like the accuracy of detail we have hitherto done; nor shall we be able to trace any bed or set of beds whatever, over any large space, or to clearly identify those found in one place with those of any other locality.

We will first of all continue our exploration to the north.

We have seen that the Bottom coal and the beds immediately above it are worked continuously from the neighbourhood of Bilston and Wolverhampton under the Bentley and Bloxwich districts, up to Pelsall and the Brown Hills; and that as they range from the former towards the latter, the measures increase in thickness, and beds which lie together in the southern part are, as they run north, split up by intervening measures, and sometimes widely separated from each other. I will now proceed to show that the same is the case with the Thick coal and the beds just beneath it. It will be remembered that between Bilston and Wolverhampton the Thick coal is already separated into two masses by an intervening bed of shale 10 feet thick, called "Hob and Jack." The measures rise from this gently towards the north, and crop out successively until at Bentley Hall and Deepmore Coppice the Bottom coal is but a little way below the surface of the ground.

A little north of Deepmore coppice a great fault running nearly east and west throws down the measures to the north to the extent of 360 feet, so that the Bottom coal is then about 400 feet deep, with all the measures above it easily recognisable up to the Heathen coal, which is there about 144 feet deep. Now, as the Heathen coal about Bilston is never more than some 30 feet below the Thick coal, it follows that we ought to have, north of the Bentley fault, the Thick coal itself some 80 or 90 feet below the surface. What is really found there is the following:

	FT.	IN.
1. Soil, gravel and clay	21	11
2. Coal (called Old man's coal)	9	7
3. Fire-clay, clunch, rock, and binds	54	0
4. Little coal	1	10
5. Fire-clay	0	8
6. Coal (called Bentley Hay coal)	5	0
Carried forward	93	0

	FT.	IN.
Brought forward - -	93	0
7. Fire-clay, rock, and binds - -	10	1
8. Ironstone (called the Binds) - -	1	7
9. Coal (called the Binds coal) - -	1	2
10. Clunch and binds - - -	6	6
11. Gubbin ironstone - - -	1	9
12. Gubbin coal and batt - - -	1	2
13. Fire-clay - - - -	0	10
14. Coal - - - - -	0	7
15. Binds - - - -	21	0
16. Clunch and ironstone (Lambstone) - -	3	0
17. Black batt - - -	0	11
18. Coal (Heathen coal) - - -	1	8
	143	3

Of this set of beds, No. 11 is the same as the Little Gubbin already described farther south. It has, however, here two small coals below it, and the thickness between it and the Heathen coal is 4 or 5 feet greater than the thickness about Bilston.* There is above the Little Gubbin, moreover, another small coal and ironstone (here called the Binds coal and ironstone) of which we have little or no trace to the southward;† and we must look upwards of 19 feet above the Little Gubbin (instead of only 5 or 6, as near Bilston,) before we meet with any considerable bed of coal. We then get two beds of coal 7½ feet thick together, including 8 inches of fire-clay between them, over which are 54 feet of alternations of fire-clay, clunch, binds, and rock, and then another bed of coal 9 or 10 feet in thickness. It is clear, nevertheless, from their position above the Heathen coal, that these latter coals, namely, No. 6, the "Bentley Hay," and No. 2, the "Old man's" coal, notwithstanding their being 54 feet apart, must be the representatives of the lower beds of the Thick coal.

* It will be recollected that some distance south of Bilston, around Dudley for instance, the beds between the Little Gubbin and the Heathen coal thin out to nothing, and the ironstone measures rest directly on the coal.

† There are sometimes small beds of ironstone both above and below the Little Gubbin in the southern part of the field, as at Claycroft, near Dudley, see p. 189.

Now, the Bentley Hay coal, and the Heathen coal below it, are found at intervals, and worked, north of Bentley, up to the New Invention. They have never been worked quite continuously, as they are said to be frequently thrown in and out of the ground, not only by a succession of small faults, but also by several undulations of the beds.

* In the canal, just south of Sneyd Reservoir, the crop of a coal was seen, 8 or 9 feet thick, which was believed to be the Old man's coal of Bentley, and the same coal, it is believed, crops at intervals across Essington Wood up to Newtown, and thence northwards towards Jacob's Hall. This coal dips gently towards the west; and in that direction, at the coal-pits near the Old Mitre, an 8-foot coal was worked about 280 feet deep. This coal was known to be the same with a bed, which at Wyrley, 3 miles to the northward, is called the "Bottom coal,†" and the Wyrley Bottom coal is known to crop to the surface, near Jacob's Hall.

It appears from this, with a very high degree of probability, that the Wyrley Bottom coal is the same as the Bentley Old man's coal, and therefore part of the Thick coal of the southern portion of the field.

This probability is increased by the fact that the true "Bottom coal" is worked at Brown Hills about 3 miles east of Wyrley, and that it dips there gently towards the west, and must therefore pass some distance under the "Wyrley Bottom coal," unless some large fault or undulation of the beds exist in the intervening space, and of such an occurrence there is no evidence at all. It will be seen too, in the sections given below, that underneath the Wyrley Bottom coal there are at least 323 feet of coal-measures in which there are several small coals that may represent the New mine, Fire-clay, or Bottom coals, in a thin and debased form. That the coals of Brown Hills, &c., do assume such a form, as they dip towards the west, is rendered probable from the fact that the upper part of the "Shallow coal," which

* On the information of Mr. George, mine agent of Bentley.

† On the information of Philip Baker, an old and intelligent ground bailiff of Landywood, since deceased.

between Pelsall and Brown Hills is 5 feet thick, thins out and comes to nothing before it reaches Fishley.

In whichever direction, therefore, we work towards Wyrley, whether from the upper measures, near Bentley, or from the lower at the Brown Hills and Pelsall, we see reason to conclude that the Coal-measures at Wyrley must belong to the upper part of the series, and ought to contain the Thick coal or its representatives. Now, the actual section at Wyrley is the following:—The first part of which is derived from a newly-sunk pit at the Waterloo colliery at Longhouse, near the Walk Mill, and the lower part from a boring made in 1826 by Mr. John Gilpin, and under the superintendence of the late Philip Baker of Landywood.

Section at Longhouse.

	FT.	IN.
1. Red sandy rotch, perhaps part of New red sandstone	35	6
2. Alternations of clunch, grey rock, and black batt	101	0
3. Coal and batt	1	9
4. Rock and clunch	10	0
5. Coal and partings (this coal not known in other pits at Wyrley)	5	10
6. Dark clunch	1	11
7. Coal	2	0
8. Fire-clay, clunch, and rock	74	0
9. Coal (old Robins coal)	6	6
10. Various measures	84	0
11. Coal (probably the Charles coal)	3	0
12. Various measures	54	0
13. Coal (Cannel coal)*	3	6
14. Various measures	81	0
15. Coal (Brooch and Benches)	7	0
16. Various measures	48	0
17. Coal (called Bottom coal)	7	0
	526	0

* This part of the section is taken from some adjacent pits, as at Longhouse the Cannel coal was absent.

The boring from the Bottom coal continued as follows:—

		FT.	IN.
18.	Clunch, with occasional ironstone	40	7
19.	Coal (believed to be Bentley Hay coal, and therefore the base of the Thick coal)	3	0
20.	Fire-clay, and alternations of clunch and rock	113	6
21.	Coal	2	3
22.	Beds of clunch, with small ironstones and some beds of rock	68	8
23.	Coal	1	5
24.	Alternations of clunch, with little ironstone and some rock	38	3
25.	Coal	2	0
26.	Fire-clay, rock, and clunch	30	2
27.	Coal	0	4
28.	Fire-clay and clunch	10	2
29.	Coal	1	6
30.	Fire-clay and clunch	4	2
		316	0
	Which with	526	0
	Makes a total of	842	0

We may here remark that a vertical section of 840 feet or 280 yards of Coal-measures, containing beds of coal throughout at pretty regular intervals, is unexampled in the South Staffordshire coal-field, unless we include in it the Thick coal, and then only by supposing the Thick coal to be split up into several beds, with a good thickness of other measures between them. It is remarkable, also, that if we add together the thickest coals of Wyrley, and those between them, and add on to them the coal below the Bottom coal, which is believed to be the Bentley Hay coal, and therefore the base of the Thick coal, we shall get a thickness of just 30 feet, as follows:—

	FT.	IN.
Old Robins coal	6	6
Charles coal	3	0
Cannel coal	3	6
Brooch and Benches	7	0
Bottom coal	7	0
Bentley Hay (?) coal	3	0
	30	0

If this be anything more than an accident, and we can consider the Old Robins coal as the top of the Thick, the coal above (No. 5 in the section) may represent the Brooch coal of the main part of the field.

I possess five other pit sections at Wyrley, which exhibit some difference in the details, not only from the one given above, but among each other. I add abstracts of them, therefore, for the sake of recording them, whether for theoretical or practical purposes.

*Section of Mr. Gilpin's pits between Church Bridge and Wyrley Bank.**

		FT.	IN.	
1.	Upper measures	30	0	
2.	Robins coal	8	0	
3.	Fire-clay and ironstone balls	18	0	
4.	Yard coal	3	0	
	Fire-clay	1	6	
	Coal	0	9	
5.	Fire-clay, clunch, and binds	45	0	
6.	Charles coal	3	0	
7.	Fire-clay, binds, &c.	28	6	65 ft. 4 in.
8.	Coal (flying coal)	1	0	
9.	Fire-clay, binds, &c.	36	10	
10.	Cannel coal	4	0	
11.	Fire-clay, binds, &c.	74	0	
12.	Brooch coal 3 9			
	Clod 1 6	7	6	
13.	Benches coal 2 3			
14.	Fire-clay, rock, clunch, &c.	48	0	
15.	Bottom coal	8	0	
		317	1	

Section of Mr. Gilpin's new pits in same locality.

		FT.	IN.
1.	Clay, shale, &c.	30	0
2.	Robins coal	8	0
3.	Black batts, with ironstone balls	22	0
4.	Yard coal	3	0
5.	Fire-clay, batt, and binds	69	0
6.	Charles's coal	3	0
7.	Binds and rock	64	0
	Carried forward	199	0

* Given me by Mr. Gilpin, and Jesse Potts, his ground bailiff.

	FT.	IN.
Brought forward	199	0
8. Cannel coal	4	0
9. Binds, &c.	84	0
10. Brooch coal 4 0		
Rubbish 1 0	7	3
11. Benches coal 2 3		
12. Binds, &c.	40	0
13. Bottom coal	8	0
14. Binds, &c.	39	0
15. Another coal	3	0
	384	3

Section of Mr. Gilpin's pits, near the Cock public-house.

	FT.	IN.	
1. Soil and clay	13	6	
2. Clunch and batt, with ironstone	6	7	
3. Old man's coal=Yard coal	3	9	
4. Fire-clay, batt, and clunch, with Grub ironstone	19	6	
5. Flying coal	1	0	35 ft. 6 in.
6. Fire-clay, binds, &c.	15	0	
7. Charles coal	2	4	
8. Fire-clay and clunch	15	6	
9. Flying coal	3	0	54 ft.
10. Fire-clay, binds, and clunch	35	6	
11. Cannel coal	3	11	
	119	7	

Section at the Double pits, near Hall's House, at Wyrley.

	FT.
1. Soil, binds, &c.	96
2. Charles coal	3
3. Binds, &c.	57
4. Cannel coal	3
5. Binds, &c.	54
6. Benches coal	7
7. Binds, &c.	48
8. Deep or Bottom coal	6
	274

*Section at Mr. Yates' colliery at Wyrley.**

	FT.	IN.	
1. Soil and gravel	12	0	
2. Clunch and binds 12 0			
3. Flying coal 1 0	35	6	
4. Fire-clay and rock 22 6			
5. Charles coal	3	0	
6. Fire-clay and clunch 12 0			
7. Flying coal 1 6	40	9	
8. Fire-clay, binds, and rock 27 3			
9. Cannel coal	3	8	
	94	11	

* The three latter sections were given me by Mr. George, of Bentley.

Before we proceed further north we must give a brief attention to a little outlying district on the east, that, namely, between Daw End and Aldridge, north-east of Walsall. A pit was sunk as a trial pit two or three years ago in that district, a little north of the Red House, in which a number of coals and ironstones were found that could not be identified with any of the beds in the immediately adjacent country. The measures dipped north at a considerable angle from the fault which bounds the Silurian district on the south of them. It is not, therefore, at all likely that these coals could be any of the lower part of the coal measures, as, if the rise of the beds were the same for any distance to the south, much lower beds and a considerable thickness of them must crop out from underneath those found in the trial pit. It is à priori probable, therefore, that they either represent the Thick coal or beds still higher in the series. A detailed section of this Aldridge pit is given in the Vertical sections, sheet 16, No. 4, and on comparing it with a part of the Wyrley section a very strong similarity will be observable. The thicknesses in the following abstracts are reduced to yards for the sake of eliminating the minor differences:—

Wyrley.	YARDS	*Aldridge.*	YARDS
1. Coal	0½	1. Coal	0½
Intermediate measures	3½	Intermediate measures	3½
2. Coal	2	2. Coal	1½
Intermediate measures	26	Intermediate measures	29
3. Coal (Robins)	2	3. Coal	1
Intermediate measures	28	Intermediate measures	11½
4. Coal (Charles)	1	4. Coal	1½
Intermediate measures	18	Intermediate measures	12
5. Coal	1	5. Coal	2
Intermediate measures	27	Intermediate measures	21½
6. Coal	2⅓	6. Coal	2
Intermediate measures	16	Intermediate measures	7
7. Coal	2	7. Coal	1
	129⅓		94

I do not by any means intend to *assert positively* that the coals are identical in the two localities, or that the seven beds mentioned above were ever continuous from one place to the other; but there is a sufficient general resemblance in the two sections

to warrant the belief that they occupy nearly the same place in the series. We have seen reason to believe that this place, with regard to the Wyrley sections, includes that of the Brooch and Thick coals of Bilston, &c.; it is therefore probable that these coals at Aldridge, or some of them, are the representatives of the Thick coal. The fact of the Aldridge being much richer in ironstone than the Wyrley section is no objection to such a view, since it is well known that ironstones are of all beds the most frequently capricious in their occurrence and the relative richness of their contents.

Proceeding now towards the north we come to the new colliery called the Hammerwich colliery, immediately east of the dam of Norton reservoir on Cannock Chase. The section here is very nearly the same as that at the Brown Hills close by (see Vertical sections, sheet 16, Nos. 2 and 5), and the measures are certainly identical in the two localities, and are now called by the same names.

The following are abstracts of the sections in the two localities, the upper part of the Hammerwich down to the Bass coal being taken from a new pit now in progress on the north side of the reservoir:—

*Brown Hills.**	FT.	IN.
1. Upper measures	99	0
2. Sulphur coal	1	0
3. Fire-clay and rock	32	0
4. Yard coal	3	0
5. Fire-clay and rock	45	0
6. Bass coal	6	0
7. Fire-clay and rock	29	0
8. Cinder coal	5	0
9. Grit rock	21	0
10. Shallow coal	6	0
11. Fire-clay and rock	48	0
12. Deep coal	5	0
	300	0

Hammerwich Colliery.†	FT.	IN.
1. Upper measures and drift	113	0
2. Sulphur coal	1	1
3. Fire-clay, binds, and peldon	42	3
4. Yard coal	3	6
5. Fire-clay, binds, and work	51	0
6. Bass coal	6	0
7. Fire-clay and binds, with one small coal	31	11
8. Cinder coal	4	3
9. Fire-clay and binds, with little coal	39	10
10. Shallow coal	7	1
11. Fire-clay and binds	50	1
12. Deep coal	6	3
	356	3

* Given me by William Arblaster.

† Given me by the late Mr. Figgins, and by Mr. Landor, the Marquis of Anglesea's present manager.

We here get yet another example of the thickening of the measures towards the north, the thickness from the top of the Sulphur to the bottom of the Deep coal being 201 feet at the Brown Hills and 243 ft. 3 in. at the Hammerwich colliery, which is about a mile further north. The reader will recollect that at about three or four miles south of the Brown Hills the Yard coal and the Bass coal come together to form the New mine coal, the Cinder coal is called the Fire-clay coal, and the Shallow and Deep coals come together to form the Bottom coal.

Of the rest of Cannock Chase but little account or valuable information can now be in any way obtained. Old works have, I believe, been carried on about Norton, but no record has been kept of them. At Cannock mill, just east of Cannock, there were some coal-pits a few years back worked by Lord Hatherton, of which I got the following section from the recollection of Abraham Ward, well-sinker at Cannock:—

		FT.	IN.
1.	Red marl	6	0
2.	White binds	12	0
3.	Cannel coal	3	6
4.	Bind measures	24	0
5.	Rock	3	0
6.	Two-foot coal	2	0
7.	Binds, rock binds, clunch, &c.	72	0
8.	Coal	4	6
9.	Measures	90	0
10.	Stinking coal	5	0
		222	0

We cannot with any degree of certainty identify any of these beds with any of those at Wyrley.

Just south of the hamlet of Hednesford there are some old coal workings, of which I got the following section from W. Hayock, an old collier at Brereton:—

		FT.	IN.
1.	Gravel	20	0
2.	Clod	12	0
3.	Yellow rock	42	0
4.	Clod	10	0
5.	Coal	7	0
6.	Clod containing good ironstone	90	0
7.	Coal	4	0
		185	0

On the same authority, the measures at the old Botany Bay colliery, just north-west of Hednesford Pool, were,—

	FT.
1. Running sand	51
2. Clod	99
3. Coal	5
4. Clod	30
5. Coal	3
	188

The same person also gave me the following scraps of information:—

Section between Heathy Leys, Wimblebury, and Cooper's Lodge.

	FT.	IN.
1. Gravel	12	0
2. Clod	90	0
3. Cannel coal	1	4
4. Clod	6	0
5. Coal	4	0
	113	4

Section between Sugars Lodge and Lodge Barn in Beaudesert Old Park.

	FT.	IN.
1. Waterclay	6	0
2. Clod	60	0
3. Coal	5	0
Under which they bored down through many measures containing 9 coals	360	0
	431	0

He also told me, that at Noddyfield, near Mr. Cocking's house, there was the same section as at Hednesford, the 7 foot coal being 51 feet deep at Noddyfield, instead of 84, as at Hednesford. As Noddyfield is much higher ground than Hednesford, there must, if this information be correct, probably be a gentle westerly or north-westerly dip over all the intervening space.

I procured an old section from the late Mr. Figgins, of Brereton Hays, mine agent to the Marquis of Anglesea, which was taken either at Noddyfield, or in the Old Park of Beaudesert, most probably the former. In either case it does not go greatly against W. Hayock's evidence, and in the latter tends to confirm it.

The following is an abstract of this section:

	FT.	IN.
1. From surface to the bottom of a coal of which the thickness is not stated - -	90	0
2. Clunch, binds, fire-clay, rocks, &c., with three little 9-inch or foot coals intervening - - - -	70	6
3. Coal - - - -	4	0
4. Rock, binds, &c. - - -	25	6
5. Coal - - - -	2	0
6. Fire-clay, binds, rock, clunch, &c. -	39	0
7. Coal - - - -	4	0
8. Fire-clay - - - -	0	0
	235	0

This section evidently passes through the same measures as those which are now being worked near Brereton, about three miles to the northward. Of these measures I have had sections supplied to me by Mr. George, of Bentley; Mr. Vernon Poole, of Brereton, Lord Talbot's agent; and by the late Mr. Figgins. These sections are so nearly identical that they seem all to have come from the same source, and to apply equally to all the Brereton district. The section now engraved in Vertical sections, sheet 16, No. 1, will give the details, but I add here an abstract:

Brereton Section.

	FT.	IN.
1. Red and white gravel (part of the New red sandstone conglomerate) - -	80	0
2. Red and yellow marl, rock, clod, and batt	16	6
3. First coal - - -	4	6
4. Clod with ironstone - - -	19	10
5. Second coal - - -	2	6
6. Clod and rock - - - -	51	3
7. Third coal - - -	2	0
8. Fire clay and clod - - -	13	0
9. Fourth coal - - -	4	0
10. Rock clod and ironstone - -	30	1
11. Fifth coal - - - -	4	0
12. Fire-clay - - - -	3	0
Carried forward - -	230	8

Brereton Section—*continued.*

		FT.	IN.
	Brought forward - - -	230	8
13.	Sixth coal - - - -	0	4
14.	Rock with ironstone - -	14	8
15.	Seventh coal - - - -	2	3
16.	Rock with ironstone, and clod and batt -	36	6
17.	Eighth coal - - - -	4	0
18.	Batt, clod, and light rock and clod -	50	0
19.	Ninth coal - - - -	0	6
20.	Clod, &c. - - - -	6	0
21.	Tenth coal - - -	3	3
22.	Rock - - - -	13	4
23.	Eleventh coal - - -	1	0
24.	Clod, rock, and ironstone, &c. - -	22	10
25.	Twelfth coal - - -	9	0
26.	Rock, binds, and ironstone - -	48	7
27.	Coal, not enumerated - -	2	0
28.	Binds with ironstone - - -	21	7
29.	Thirteenth coal - - -	5	0
30.	Fire-clay and clod - - -	24	0
31.	Fourteenth coal - - -	1	0
32.	Rock, clod, and ironstone - - -	105	8
33.	Fifteenth coal - - -	4	3
		606	5

Below the fifteenth coal they sank some distance in red measures.

It will be at once seen from the inspection of this section that it is not possible, from the mere thickness and relative position of its beds, to discover any relation between it and any of those we have examined in the southern part of the field. I will, however, state my opinion, arrived at perhaps rather negatively, than from any positive data, that we have in these Brereton coals the representatives of the Thick coal of Wolverhampton, that the beds generally are the same as those of Wyrley, the subdivision of the coals being still further carried out. This opinion must only be taken loosely, as a guess rather than an opinion; it is, however, rather strengthened by the fact, that the total amount of all the beds of coal at Brereton, namely,

49 feet, is nearly the same with their total amount at Wyrley, namely, 46 feet.*

Before closing my account of the Coal-measures, I must just mention two little outlying districts of that formation on the south of the field,—one is near the Lickey Hill where small patches of Coal-measures with one or two little bands of coal were found on each side of the quartz ridge, near the New Rose and Crown.

Another is near the Stone House, south-west of Harborne. At this latter locality Mr. Flavell sank 80 yards through true Coal-measures, grey shales, with nodules of ironstone, but without traversing any bed of coal. It is obviously impossible to say what part of the general series of Coal-measures those found at these two localities belong to.

5. *The Silurian Rocks.*

Of the Silurian formation we have, in or near the South Staffordshire coal-field, parts of three different subdivisions:—

1st. A portion of the Ludlow rocks containing a band of limestone, believed to be the same as the Aymestrey limestone.

2d. The Wenlock and Dudley rocks entire.

3d. A portion of the Caradoc sandstone.

These rocks have been so fully described by Sir R. Murchison in his "Silurian System" that there remains but little to say respecting them. The mass of the Ludlow and Wenlock rocks, or, as they might here be called, the Sedgley and Dudley rocks, consists of a brown or blueish grey argillaceous shale, always very smooth and compact, thick-bedded and regularly jointed. In the upper portion is a band of dark brown nodular and concretionary limestone, some 20 or 25 feet in thickness. It is locally called the "brown lime." From its containing the *Pentamerus*

* Near Dudley, the total amount of all the coals would be about 57 feet. The richest part of the field in amount of coal beds, both absolutely and still more in proportion to the whole thickness of the measures in which they lie is between Wolverhampton and Bilston, where the lower coals are becoming rapidly thicker, and the Thick coal is still unbroken and undiminished. The total amount of the coals in a vertical section there would in some places be upwards of 70 feet.

Knightii, and from its position, it is with great probability identified with the Aymestrey limestone. This limestone shows itself at Sedgley, at Turner's Hill and at the Hayes near the Lye Waste, 2 miles east of Stourbridge. At a certain depth below this, is the Wenlock and Dudley limestone, which is locally called "white lime."

What is the exact thickness intermediate between these two limestones, or how far they are apart, we have no means of determining. In the only place where they both crop to the surface together, namely, at Sedgley Beacon and Hurst Hill, a fault runs between the two which has been traced on one side in the workings, but without arriving at any means of determining the amount of its "throw." I have, however, assumed 800 or 1,000 feet as the distance between them. This distance enabled me to draw the sections, with the least amount of dislocation and disturbance of which there was no decided evidence; but I feel by no means confident that that thickness ought not to be either diminished or increased.

It is equally impossible to draw any boundary in the shales between the Ludlow and Wenlow rocks, partly from want of sections, partly that the whole mass of shale of the two subdivisions is so nearly of the same character throughout, that any line must be a purely arbitrary and hypothetical one.

The Wenlock and Dudley limestone forms two bands of solid concretionary and flaggy limestone, with many calcareous nodules, concretions, and small flaggy beds, both between, above, and below them.

At Dudley, we have the two following sections of the limestone given in the Silurian System:

The Castle Hill.	FT.	IN.
Upper limestone, or thin measures - - -	23	1
Intermediate shale -	—	
Lower limestone, or thick measures - - -	35	7

The Wren's Nest.	FT.	IN.
Upper limestone - -	28	4
Intermediate shale -	90	0
Lower limestone - -	42	3

At Hurst Hill, the beds are collectively thinner and the limestones closer together. At Mr. Bagnall's limestone pits at Dudley

Port they found two bands of limestone,—upper, 27, and lower, 24 feet thick,—resting directly one on the other. At Mr. Giles's pit. however, according to Sir R. Murchison, the limestone worked was 21 feet thick, and they reached, by boring, another mass of limestone 150 feet below it. At Deepfields, a little east of Hurst Hill, according to "Smith's Miner's Guide," they sank below the Coal-measures through 150 feet of blue rocky clunch, probably Silurian shale, and then came on limestone in about ten beds of nearly 3 feet each.

In the neighbourhood of Walsall the Dudley and Wenlock limestone consists of—

	FEET.
Thin or upper limestone - - -	12
Intermediate shale, &c. . -	120
Thick or lower limestone - - -	34

In this neighbourhood (Walsall) the Dudley limestone crops out at a gentle angle, and the lower shale rises from underneath it, spreading out to the east over a tract nearly 2 miles in width, till another band of limestone rises to the surface at Hay Head, near Great Barr. There is but little to be seen in the space between these two limestones, but where seen, as in the cutting of the new canal that runs from Hay Head to the Tame Valley, the shale was always found in a nearly horizontal position. This lower or Barr limestone rises from beneath it at an angle of about 8° or 10° on an average. Drawing the section from these data, I place the Barr limestone at a depth of about 500 or 600 feet below the Dudley limestone, though it may easily be much more.

In mineral character, the Barr limestone much resembles that of Woolhope* in Herefordshire, which is at the junction of the Wenlock and Caradoc rocks, and it may very easily be at or near the actual base of the Wenlock rocks as they exist in Staffordshire.

In this case we ought to have the Caradoc sandstone rising out immediately to the east of the Barr limestone. Nothing,

* I state this on the authority of Professor Ramsay, who on one occasion accompanied me to Hay Head, and who was perfectly acquainted with the Woolhope limestone, a district I never had the good fortune to visit.

however, can be seen there, from the flat and unbroken character of the surface, until we cross the great boundary fault and find ourselves on the New red sandstone.

Caradoc Sandstone.—In the Lower Lickey Hills, between Birmingham and Bromsgrove, we find a ridge of quartz rock determined by Sir R. Murchison to be altered Caradoc sandstone. I can add nothing to the full and accurate description of this rock and neighbourhood which is given in the "Silurian System," and shall, therefore, content myself with the following quotations from it:—

"On first examining the tract in 1834, I observed, that at two points on its eastern and south-eastern flank (Colmers and Kendal End) the quartz rock was overlaid by a limestone and shale which contained some corals and shells of the Wenlock formation. At Kendal End, the solid limestone extracted, 23 years before, did not exceed a yard in thickness, but it was accompanied by small concretions called 'batch cakes.' The existence of another thin band of limestone was ascertained by sinking for coal at the Colmers." * * * "The sheds of coal and shale," * * * "were easily penetrated; and the sinkings were continued through a thin layer of impure limestone, only 13 inches thick, which, from its appearance and organic remains, I consider to be one of those calcareous courses which underlie the Wenlock shale, and form the top of the Caradoc sandstone (Woolhope limestone)." * * * "After penetrating this limestone, the coal speculators sunk till they were stopped by a hard quartzose sandstone and reddish slaty clay, similar to that which rises on the eastern flank of the quartz hills. Near the southern extremity of Snead's Heath, the cutting of a new road exposed a reddish siliceous sandstone, made up of rounded grains of quartz, containing casts of characteristic Caradoc fossils. These fossiliferous sandstones having in themselves a half fused appearance from the upper portion of the true quartz rock of these hills, into which they graduate insensibly at Snead's Heath, so that it is impracticable to draw any defined line between the reddish fossiliferous sandstone and the quartz rock."

The thickness of the quartz rock of the Lower Lickey must be several hundred feet, at least.

Igneous Rocks.

There are two, or perhaps three, varieties of igneous rock in the district; namely, basalt, greenstone, and a white felspathic-looking trap. All three, however, are different parts of the same great mass of molten matter, their variety depending pro-

bably more on the conditions under which they have been placed than on any difference in the origin or mineral constitution of the rocks themselves.

The "Rowley rag" is a basalt, a hard, heavy, black, close-grained rock, weathering brown outside, having a tendency to form spheroids that envelope with several concentric coats a solid ball in the middle, and consequently often assuming a columnar structure, that in some instances becomes nearly as regular as that of the Giant's Causeway. This is the stone of the Rowley Hills, Barrow Hill at Pensnett, Pouk Hill at Bentley, and other spots.

Burrowing in the coal measures, and here and there coming out to the present surface, is another igneous rock called "green rock" by the colliers. This is generally, if not always, the true "greenstone" of mineralogists, composed of felspar and hornblende,* sometimes fine-grained or compact, sometimes largely crystalline. It contains sometimes fibrous radiated masses and plates of zeolite or other similar minerals.

From it proceed dykes and veins of "white rock," which at first sight looks like a fine-grained white sandstone, but when more closely examined, appears to be a white compact felspar, with here and there a small glassy crystal of felspar embedded in it. The miners always declare that it comes from the "green rock," though I have never had an opportunity of observing the junction of the two. That it is truly an igneous rock is shown by the way in which it cuts through the coal and other matters, often producing more or less alteration in them at the place of contact.

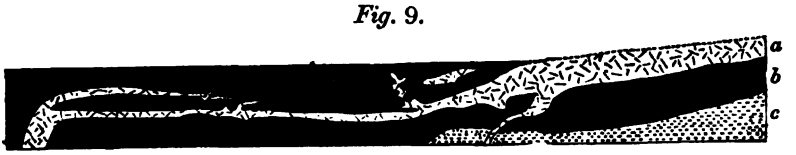
When surveying the district in 1849, I had believed in the existence of another kind of trap as a solid mass entering into the structure of the district, that, namely, of the Clent Hills. In this belief I had only followed the example of Sir R. Murchison and other geologists acquainted with the district. Our reasons for obliterating this trap from our maps, and incorporating it with the Permian rocks, will be given, postea, p. 299.

Of basaltic rocks the largest and finest exhibition is that of the plateau of the Rowley Hills. A capping of basalt 200 or 300

* On the authority of Sir H. De la Beche.

feet thick rests here upon the Coal-measures. The Thick coal has been worked round three sides of these hills, and it appears generally to dip under and pass beneath the basalt. On the north side only have they attempted to follow the coal under it; and in every instance in which this has been attempted the coal has been found to be "blacked" and to be fractured, and frequently to pass into "rock and rig." A coal is said in this district to be "blacked" when, by its near proximity to an igneous rock, it has become so altered as to lose all its brightness, and nearly, if not quite, all its inflammability. It is not exactly coke, but is dull and earthy, and on exposure to the atmosphere is very friable. It frequently in this state contains small nodular concretions of iron pyrites. I have never had the opportunity of examining a pit where the coal was thus affected, except Mr. Piercy's pit at the Grace Mary colliery, a little east of Rye Cross Farm. Here, at a depth of about 200 yards, they came into blackened coal, penetrated by long dykes of white rock trap, and more or less intermingled and mixed up with white sandstone. This white sandstone was full of little patches and shreds of coal, and the coal was frequently entangled in the sandstone, and the two mixed up together in a very singular way. This kind of sandstone is that called by the colliers "rock and rig." In one of the gate-roads of this colliery the white trap descending from the roof cut both into the coal and the sandstone, in the manner shown in Fig. No. 9.

Fig. 9.



Scale, 20 feet to 1 inch.

a The white-rock trap.
b The coal.
c White sandstone (rock and rig).

This was drawn to scale with a measuring tape, and is a sufficiently accurate representation of the facts. A little north-west of this part of the mine a fault was met with, beyond which the Thick coal was found uninjured either by trap or by "rock and rig." The only explanation of the "rock and rig"

I can offer is, that it is part of a "rock fault," a mass of sandstone contemporaneous with the coal, as described before, p. 183. Whether its connexion with the trap be accidental or otherwise it is difficult to determine. I am inclined to think, from the frequency of the occurrence of these "rock faults" in the coal in the neighbourhood of the Rowley Hills, and their absence, so far as I know, at any great distance from them, and from "rock and rig" being found around Barrow Hill, that their connexion with the trap is not accidental. It is quite possible that the volcanic focus from which was subsequently protruded the molten basalt, gave some indication of its existence, even at an early period in the formation of the Coal-measures; and that from some troubled action fracturing the rocks, and producing springs, or currents perhaps, of considerable local intensity, patches of sand were produced that locally interfered with the production of the Thick coal.

It may still happen that at some point round the Rowley Hills *good unaltered* coal may be found for some distance beneath the basalt, but at present all the known evidence is the other way.

Barrow Hill, two miles west of Dudley, is another mass of basalt in every respect similar to that of Rowley, except in extent. Immediately east of the hill, it appears, from the marks of old workings, that a piece of Thick coal cropped to the surface, and was worked in open work along it. This piece lay in an angle between the Corbyn's Hall fault and another, which is supposed to run south of Barrow Hill. In the workings to the west of Barrow Hill the coals are found to be "blacked" as they approach it, and beds of "green rock" (horizontal dykes) are found between the measures.

At Barrow Hill Coppice pits 64 feet of "green rock" penetrated the Gubbin-stone measures just beneath the Thick-coal. At the Birds Leasowe colliery, near Tansey Green, the Thick coal was found to be "mingled with rock and rig;" and, below the Gubbin measures, "green rock" was found, into which they sunk 38 feet. Between Tansey Green and Shut End furnace the "green rock" is only 36 feet thick, and comes in the place of the Heathen coal, the Thick coal itself being blacked. To the east of Barrow Hill a sheet of "green rock," which at first is more than 60 feet thick, but afterwards thins to about 30 feet, stretches for at least two miles in one direc-

tion. Its usual place is between the Heathen coal and the Whitestone measures, but between Cooper's Bank and the Fiery Holes the "green rock" cuts down under the Whitestone measures. This "green rock" crops regularly out like a bed on the rising ground west of Russell's Hall, and intrusive bosses of it rise to the surface at a spot on the western outskirts of the town of Dudley, at the Fiery Holes, at the east side of Cooper's Bank, and in the brook to the west of it.

A mass of basaltic trap is very well seen in the canal cutting south of Netherton church, where it is exposed by the rise of the beds below the Thick-coal, and is seen to send wedge-like masses into the Coal-measure sandstones.

Sheet-like masses of "green rock" (the local name for the trap) seem to spread almost uninterruptedly in the lower Coal-measures from the base of the Rowley Hills, through the centre of the district up to Wolverhampton, Bilston, and Bentley.

At one of Lord Ward's pits at Tividale (about a quarter of a mile north by west of Coxes Rough) they found, at a depth of 500 feet, the following beds:—

	FT.
1. Coal mingled with rock, representing Thick coal	24
2. White rock, *sandstone*	33
3. Strong rock	9
4. Binds	6
5. Gubbin measures	2
6. Coal mingled with rock (represents Heathen coal)	4
7. Green rock, sank into for	27

The usual distance between the Thick coal and the Heathen coal is only 12 or 14 feet, instead of 54, as here; Nos. 2 and 3 being quite unusual measures.

At Dudley Port, in Mr. Bagnal's limestone pits, they passed through 15 feet of "green rock" in the lowest sandstone of the Coal-measures, just before entering the Silurian shale.

At Tipton Moat colliery and at Tipton there were 34 feet of "green rock" at a distance of 36 feet below the Bottom coal. At Deepfields they got 20 feet of "green rock" at a depth of 39 feet below the Bottom coal. At Highfields they found the "green rock" at a depth of 66 feet below the same coal, and sank into it for 15 feet only. At Bradley, in Mr. Addenhook's colliery, they found the "green rock" 55 ft. 6 in. thick at a depth below the Bottom coal of 24 ft. 6 in.

Near Bilston, in a pit in a field called Crabtree piece, Messrs. W. and J. W. Sparrow found 15 feet of "green rock" 22 feet below the Bottom coal; and at the Wallbutts colliery the "green rock" was struck 27 feet below the Bottom coal, and sank into for 10 feet.

No "green rock" has been seen cropping to the surface on the rise of the lower measures on the north-east flank of the Dudley and Sedgley ridge; nor, so far as I am aware, has any been met with east of Darlaston or Wednesbury, or about West Bromwich, either at the surface or underground. A considerable boss of it is seen, however, in the canal bank between Moxley and the Broadwater furnaces, which must cut up through the Thick coal and the beds above it to reach the surface. It may also have been met with in other situations in the workings, of which the record is now lost.

In the district between Wolverhampton and Walsall "green rock" is frequently met with in sheets in the lower measures, varying in thickness from 15 feet to 80 and 90 feet. In the southern part of this tract it lies *below* the Bottom coal, but between Wolverhampton and Willenhall it cuts up through that coal; and to the north of that is always found *above* the Bottom coal, between it and the Fire-clay coal. A boss of it rises to the surface, cutting up through the New mine coal at the Heath colliery north-east of Wolverhampton, and a little north of that a large mass of it rises broadly out and forms the surface of the ground all around Wednesfield, as delineated in the map. In the Bentley district the basalt of Pouk Hill seems merely to be an irregular swelling of the bed of "green rock" that crops out a little further east along the bank of the canal. This bed is found in the underground workings for about half a mile to the westward of Pouk Hill, and for the same distance to the northward, varying in thickness from 20 feet to 40 feet, lying always just above the Bottom coal, which is often greatly injured by it. It does not extend as far east as the Birch Hills,* nor far north towards Bloxwich, nor beyond Clark's-lane to the westward, neither was any found in Messrs. Bates's pits at the Trentham colliery between Mumber-lane and Wednesfield.

Near Wolverhampton none has been found in the Rough Hills, Cockshutts, or Parkfields collieries. At the Chillington colliery it is found, however, sometimes above sometimes below the Bottom coal, and varying from 15 feet to 30 feet in thickness.

I was assured by Evan Lloyd, the ground-bailiff of the Chillington colliery, of there being here two distinct beds of "green rock" there, as in the two following sections:—

Western part of the Chillington Colliery.	FT.	*Eastern part of the Chillington Colliery.*	FT.
1. Black and white ironstone	3	1. Black and white ironstone	3
2. Bottom coal - -	12	2. Green rock, about - -	15
3. Clunch - - -	24	3. Bottom coal - -	12
4. Gubbin and balls ironstone	8	4. Clunch - - -	24
5. Slums - - -	3	5. Gubbin and balls ironstone	8
6. Green rock, about -	35	6. Slums - - -	3
7. Hard rock - -	12	7. Hard rock - -	12

* Beyond the Birch Hills furnaces, however, near Birch Hills Hall, trap is again found in the Coal-measures, about or above the place of the Bottom coal.

Notwithstanding these facts the Gubbin and balls ironstone was worked continuously over the whole colliery without meeting any green rock. In this locality, therefore, there could have been no cutting up of the green rock through the measures, though it is by no means sure that these two sheets may not have a connexion elsewhere.

I was assured also by almost every one engaged in the works of this neighbourhood that, notwithstanding the variations in thickness of the "green rock," there was no change in the total thickness of the measures; that, for instance, the thickness between the New mine coal and the Blue flats ironstone remained the same, whatever might be the variation in the thickness of the "green rock." In other words, it was affirmed almost universally that the "green rock" not only intruded between the measures, but *obliterated* a mass of beds equal to its own thickness. This assertion was so confidently made by almost every *practical man* in the neighbourhood, that, however incomprehensible, I should have received it as true, had not an analysis of the materials received from them enabled me to disprove it. It is no doubt founded in fact; the greater the thickness of the intruded trap rock, the more intense, probably, would be the squeeze, and the consequent contraction given to the adjacent beds. Beds of coal, too, might certainly be nearly or altogether annihilated by the intrusion of molten rock, but we cannot conceive sandstone or clunch being thus destroyed. The truth is, that the original thickness of the measures was itself very variable, and it probably happened that, in one or two of the places where the facts were first observed, a partial thickening or thinning of the trap rock compensated for the reverse in the original beds. It may also have happened that the very fact of there being a local thinning of some of the upper measures gave occasion for a corresponding thickening of the intruded trap rock. That, however, the assertion before mentioned is really not borne out by the facts as to all places, may be shown by the following deductions from the pit sections furnished me in the district.

In six shafts in the Stow Heath colliery, partly in the occupation of Messrs. Sparrow, partly of Messrs. Ward, we find the following values for the thickness of the "green rock," and for the thickness of the whole measures, including the "green rock," from the top of the New mine coal to the top of the Blue flats ironstone :—

Pit.	Green-rock.	Total beds from New mine coal to Blue flats.
	FT.	FT.
1.	30	164
2.	33	157
3.	51	205
4.	55	177
5.	66	204
6.	66	214

which shows that the total thickness does increase with the increase of the thickness of "green rock," although not regularly or in strict pro-

portion, owing to the original irregularity in the thickness of the other measures.

In three pits at the Portobello colliery, just where the "hole" of "Moseley Hole," is engraved in the map, all three pits being within a distance of 264 yards, we get the following thicknesses:—

Pit.	Green-rock.	Total from New mine coal to Blue flats.
1.	52	168
2.	56	164
3.	84	190

In which we find the increase in the total thickness to be very nearly in direct proportion to that of the green rock.*

In an open work in the New mine coal, some years ago, on Wednesfield Heath, a dyke of white feldspathic trap was seen cutting up into the coal from below, and ending in some black shale. In some quarries north of Willenhall the same rock may still be seen in veins cutting through the Coal measures.

In the northern portion of the coal-field north of Wednesfield and Walsall, for instance, no trap rock is known to show itself at the surface of the ground, with the exception of a little spot of hard dark hornblendic trap at the Essington Wood brick-kiln, only to be seen in a small quarry partially concealed by underwood, and surrounded by the red rock of the Permian formation.

Much "green rock" was found in some old sinkings between Pool Hayes and the New Invention, obliging the works to be abandoned. I was informed that in some sinkings made by Colonel Vernon 2 or 3 miles north of Bloxwich on Essington Wood, the measures were found to be disturbed and altered by "white rock trap," to such an extent as to oblige them to abandon the undertaking. Large intrusive masses of this white trap also are found in the pits near Birch Hills Hall, north of Walsall. At Union colliery, north of that, the Bottom coal is cut entirely out by "green rock;" and at Goscott, still farther north, there are 6 yards of "green rock" restin directly on the Bottom coal. In the rest of the field, I have found no trace of the rock having been met with, and it certainly has not been seen in any of the Brereton workings at its northern apex.

Now, as to the age of these trap rocks. As they are all intrusive, and all alter the rocks adjacent to them, it is clear

* I have insisted a little more strongly on this point than its real importance deserves, because it is a good illustration of the error into which purely practical men are so apt to fall, that, namely, of over-hasty generalisation from insufficient data. The charge of "theorising," as it is called, is so often brought as a criminal charge against scientific men, that it is but fair to show those instances in which theory necessarily leads to truth, and therefore to safety, in order to counterbalance those in which it may occasionally have led to danger or expense.

that they must be newer than those rocks. There is, however, nothing to warrant us in believing that the trap rocks which intrude into the Coal-measures are more recent than the *Coal-measure period.* Some of the sandstones in the southern part of the field are made up of the débris of trappean materials. Some of these fragments may be of the nature of trappean ash; at all events they show the existence of trap rocks in the immediate neighbourhood. These sandstones are high in the series, for the most part from 600 to 900 feet above the Thick coal. I have, however, seen some trappean sandstones, or ashey beds, where the Thick coal was not more than 300 or 400 feet deep, about the horizon probably of the Rowley basalt. I am inclined, therefore to consider that the Rowley basalt, while it is certainly intrusive as regards the rocks below it, may possibly be contemporaneous with some of those on or above its horizon; that it was erupted and spread out during the formation of the rocks which lie from 300 to 500 feet above the Thick coal; and that the beds above that were deposited on and against the trap, some parts of them being made up of its detritus. Neither do I see any reason to oblige us to consider the other igneous masses of the coal-field as strictly contemporaneous with the Rowley trap. The trap of Barrow Hill probably is so because it occupies a very similar, if not exactly the same position; but I see no reason why the trap of Wednesfield and of Pouk Hill may not be of earlier date.

Every geologist must have felt the great physical difficulty there was to be explained as regards the injection of horizontal sheets of trap over wide areas and under the pressure of a great thickness of other rocks. If, however, we do not tie down the period of this injection too strictly, if we imagine the volcanic action to have gone on at intervals during a long period of time, commencing, perhaps, in this district, soon after the formation of the first Coal-measures and continued at intervals nearly up to that of the last, we can then understand more easily that these horizontal sheets were injected at the precise period best adapted for their production, when the intrusive force and the resisting pressure and tenacity of the rocks were so nicely balanced as to render it nearly equally easy to rend asunder a vertical fissure

and squeeze molten matter through it up to the surface, or to insinuate it between the beds, and float a certain portion of them upon it.

If the igneous rocks be thus contemporaneous, taking them altogether, with the Coal-measures taken also as a whole, it follows that the production or eruption of these rocks had nothing to do with the causing any of the lines of fracture, dislocation, or disturbance that traverse the district, because these can be proved to have been of subsequent date to the last of the Coal-measures. While it had nothing to do with causing them, however, it may have modified their result, by reason of the local accumulation of a mass of rock of a different weight or tenacity or hardness, from the general rock of the neighbourhood.

CHAPTER II.

The absolute and relative Positions of the Rocks.

In this chapter we will examine, 1st. The conformability or unconformability of the several formations to each other; in other words, the original position of each group of rocks during the period of its formation, with reference to the rocks on which it was deposited; 2d. The present dip and strike of the rocks, the anticlinal or synclinal lines that traverse them, the faults affecting them, their contortions and dislocations, &c.; in other words, the positions they have been made to assume subsequently to their formation.

In discussing these questions, it will be more convenient to begin with the lowest group of rocks, and work upwards.

1. *Conformability or unconformability of the rocks.*

I shall assume the conformability among themselves of the several members of the Silurian system in South Staffordshire. This is rendered probable by their conformability in the neighbouring district of Shropshire, and there is no evidence against it in Staffordshire. Starting with that assumption, we must necessarily conclude that before the Coal-measures were deposited the Silurian beds had been slightly tilted at one end, namely, on the eastern side, and made to dip towards the west, and that their surface had suffered considerable denudation. The uppermost members of the Silurian system, or the Ludlow rocks, are only found on the western side of the main part of the coal field. If we draw a nearly north and south line, starting from Ettingshall Park farm, running between Hurst Hill and Sedgley Beacon, and continue it down through Cradley to the south, we find that to the west of that line, wherever the Silurian rocks rise to the surface, namely, at Sedgley, at Turner's Hill, and the Lye Waste, they consist of the Ludlow or upper division; while all to the east of that line, wherever the

Silurian rocks rise to the surface, or have been reached by shafts through the coal measures, they consist of the Dudley and Wenlock, or lower division of the upper Silurian series. The farther we go east, moreover, from this line, the more nearly do the Dudley limestones rise into proximity to the Coal-measures and to the surface, until at Walsall they crop broadly out, and the shales below them still rising gently to the east, there comes out at Hay Head, near Barr, a lower limestone than has been seen in any other portion of the district.

South of the true coal field lies the Silurian district of the Lickey, where somewhat lower rocks still than the Barr limestone are found at the surface. These also were elevated and denuded before the Coal-measure period, as we find thin Coal-measures resting directly upon them. We might, perhaps, from the latter circumstance, be led to imagine that the old movement of elevation had its greatest force on the *south-east* side of the main district; but it is as likely that the elevation of the Lickey was a comparatively local disturbance, and that the Wenlock and Dudley rocks may still stretch to the east of it. At all events, the general fact remains, that previous to the deposition of the Coal-measures there was here a broad and generally level plain of Silurian rocks (whether above or under water), the beds of which had a slight dip to the west, and that the Upper or Ludlow rocks ended towards the east at about the line previously mentioned. If they formed any escarpment along it, it must have been a small and gentle one.

That this gradual rise to the east was continued yet further in that direction beyond the bounds of our district, is rendered probable by the fact of rocks still older than the upper Silurian (perhaps older than any Silurian) appearing in the Warwickshire and Liecestershire coal fields, with the Coal-measures resting directly upon them. It is, indeed, highly probable that all this tract of country, together with much of the adjacent district from Montgomeryshire to Leicestershire, became dry land after the close of the Silurian period, rising, perhaps, very slowly, and undergoing a very gradual and long-continued process of degradation as it passed through the destructive plane of the sea level; and that it remained above the waters during great part of the period marked by the formation of the Old

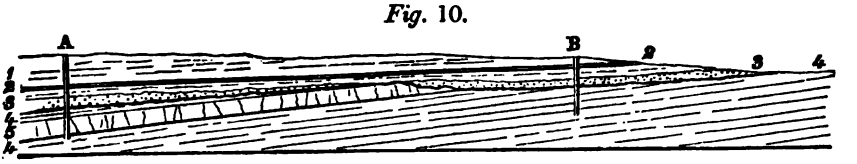
red sandstone and Mountain limestone, and that accordingly those two rocks were never deposited upon it.

However that may be, we find that when the Coal-measures of South Staffordshire came to be formed, their earliest beds were deposited on a rather rough and cliffy, but generally horizontal surface, and that the dip of the Silurians, though still markedly to the west, was so slight that their beds could not at any one place have been seen sensibly to differ in inclination from the horizontal, or nearly horizontal beds, of the Coal-measures. We have already, in examining the base of the Coal-measures, seen the way in which at particular spots the lower beds of that formation filled up hollows in the Silurian rocks and obliterated their little pre-existing cliffs, and thus formed a smooth floor for the deposition of the upper Coal-measure beds. (see p. 218.)

The Coal-measures, then, are distinctly unconformable to the Silurian rocks, but never so much so as that their respective angles of inclination are strikingly different at any one locality.

The practical importance of these apparently quite theoretical discussions will admit of a very apt illustration in this district. If the reader will look in the map of the district, at Walsall and its neighbourhood, he will see the Silurian limestones peeping out, as it were, from under the Coal-measures here and there, and again becoming concealed by them, the Coal-measure boundary not at all strictly following the line of the limestones. Let us suppose the Coal-measure boundary to represent the outcrop of the Blue flats ironstone, which it really does very nearly, and let a sinking be made, say at the Butts near Rushall, in which sinking, after passing through the Blue flats, the limestone was found at a certain distance, say 30 yards, below it; a person not understanding the fact of the unconformability of the two formations, might, after getting the Blue flats further east near Candy-fields, sink down again for the limestone, and feel absolutely certain of reaching it at some depth not varying greatly from 30 yards. Instead of finding it, the pit would be sunk beyond the outcrop of the limestone altogether, as in the following diagram.

Fig. 10.



A. The first shaft.
B. The second ditto.
1. Coal-measures.
2. Blue flats.
3. Lowest Coal-measures.
4. Silurian shale.
5. Silurian limestone.

Now this very case absolutely occurred, although not exactly in the method above stated, and was described to me by Mr. Roberts, the mine agent at that very locality. It had always been a rather puzzling and incomprehensible occurrence to him, till I explained the way in which it had taken place.*

Having established the fact of the general unconformability between the Coal-measures and Silurian rocks, let us now examine the relations between the Coal-measures and the rocks above them, namely, the Permian and the New red sandstone.

1. As to the Permian.—We have already seen that in the southern part of the district we had nearly, or quite a thousand, feet of Coal-measures above the Thick coal, without including any Permian or other rock than the true Coal-measures. Now, in the sinkings at Westbromwich that have taken place within the last few years, several shafts pass down through a considerable thickness of Permian, and through a part of the Coal-measures into the Thick coal. So far, however, from there being a thousand feet of Coal-measures between the bottom of the Permian and the Thick coal, there are not more than 520 feet at the Lewisham pit, 350 feet at the Lyng colliery, 330 feet at Messrs. Davis's pits at Spon-lane, and only 30 feet or 40 feet at the Heath pits of Lord Dartmouth. We have in these facts a clear case of decided unconformability between the Permian beds and the Coal-measures. We see that after the Coal-measures had been deposited they had suffered largely and very irregularly from denudation, several hundred feet of strata having been removed at one place which were left untouched at another, before the Permian beds were begun to be deposited on them. The belief of this denudation having taken place is confirmed by the appearance of angular and rounded fragments of coal-measure rocks and pebbles of coal being found in the bottom beds of the Permian rocks at Quarry Hill near Halesowen, and at the Heath pits, Westbromwich (see Vertical sections, sheet 17, No. 17). We can hardly suppose this denudation to have

* This is one of the numerous minor difficulties in the way of intelligent practical men that I heard of while surveying this coal field that would have been no difficulties, had the knowledge of a little "practical geology" been attainable by them at an early period of life.

taken place without a previous elevation and disturbance of the beds, although, as in the other case of the Silurian rocks, this elevation may have been so steady and equable that it did not cause the Coal-measures very sensibly to incline from a horizontal position.*

It is perhaps rash to generalise from the very scanty data we possess as to the precise relations between the Permian and Coal-measures. On so important a point, however, it is, I believe, a duty to state every opinion that may be fairly arrived at. I will therefore state, as my belief, that not only near Westbromwich, but *generally* in South Staffordshire and *the adjoining counties*, the coal measures suffered very greatly from denudation before the deposition of the Permian, and that the red sandstones of that formation were largely deposited in hollows and excavations worn in the Coal-measures by this denudation; and, moreover, that this excavation and denudation had in places proceeded the length of being continued right through the Coal-measures down to the rocks below.

It may be useful, in order to arrive at a right understanding of this subject, if we discuss in detail the operations that were carried on at the celebrated Heath pits of Lord Dartmouth at Westbromwich. For this purpose we have the data given in Sir R. Murchison's Silurian System, and others partly collected by myself, but principally received from Mr. H. Johnson, Mining Surveyor, of Dudley. In the section published as No. 17, sheet 17, of the Vertical sections, the actual shaft is drawn to scale, with the measures passed through, as given in the Silurian System, p. 476. On the left or west side of the shaft the section is copied from one lent by Mr. Johnson, which he compiled from the accounts of the men engaged in the sinking of the shaft, and corrected from his own measurements; and on the east side of the shaft are delineated to scale the headings or gateways that were driven in that direction, with the jackey pits and borings that were put up and down, together with a small ground plan both of the surface and the underground operations.

The following is a succinct account of these operations. In sinking the shaft they went down for 800 feet, through red sandstones and other rocks certainly belonging to the Permian series. Below these, or at 804 feet

* A dip of even three degrees is often hardly perceptible either to the eye or to the clinometer, although it produces very large results if continued over a wide space. A bed dipping at 3° for a space of 3 miles will be 839 feet lower on the "deep" than it is on the "rise" side.

from the surface of the ground, they entered the Coal-measures, and the following beds were passed through.

		FT.	IN.
1.	Grey clunch, with streak of coal -	2	0
2.	Ditto, with batt at the bottom - -	4	6
3.	Grey clunch - - - -	18	6
4.	Grey fireclay and ironstone - -	3	9
5.	Light greenish grey and red rock, containing a thin streak of coal - - -	21	0
6.	Dark grey clunch and batt - -	4	6
7.	Dark-coloured fireclay - - -	8	6
8.	Coal - - - - -	0	6
9.	Grey fireclay - - - -	2	0
10.	Coal - - - - -	2	6
11.	Grey fireclay rock - - -	6	0
12.	Coal - - - - -	9	0
13.	Batt, gubbinstone, and table batt -	2	0
14.	Grey clunch and lambstone - -	11	0
15.	Coal, afterwards traced to sulphur coal -	2	0
16.	White ironstone ground - -	4	0
17.	Grey fireclay and ironstone - -	4	0
18.	Dark grey clunch and flattened concretions of ironstone - - - -	14	0

No. 12, the 9 foot coal, was recognised as the bottom part (slipper, and sawyer, and benches) of the Thick coal, with the Gubbinstone and Table batt thinner than usual below it. The Heathen coal seemed to be altogether wanting, as No. 15 was afterwards traced some distance to the west under the regular Thick coal, with the Heathen coal between them; it was therefore presumed to be the Sulphur coal.

In examining the engraved Vertical section, sheet 17, No. 17, the reader must bear in mind, that while the measurements and position of the beds, as found in the pits, headings, and actual explorations are certainly accurate, the lines connecting these parts may not be exact representations of nature. They are probably only approximations to the truth, especially the shapes and positions of the coals to the west of the shaft, and the line marked "general boundary of the rock fault" on the east.

A "heading" was then driven in No. 12 for about 50 yards to the south-south-east, when the coal was found to thin out by the descent of its roof and come to nothing. A second heading was then driven 140 yards to the east-south-east, through Coal-measures lying in a very irregular condition, and at the end of that heading a bore hole was driven upwards, which at 12 or 15 feet above the heading passed through a 3 foot coal, and was continued through dark clunch, for a total height of 100 feet, up into the "red rock." A third heading was then driven nearly parallel to this for about 35

yards, and at the end of it a "jackey pit"* was sunk for 81 feet, through fireclay and sandstone, and from the bottom of that a boring was made for 180 feet lower. This bore hole was said to pass almost entirely through "Bavin measures," (by which Silurian shale is meant,) and these were said to be "very strong towards the bottom, in fact, defied all attempts to bore lower."† A fourth heading was then driven to the east by north for about 170 yards. This, after passing through the 9 foot coal before described, "went level away for 70 or 80 yards through an intermixture of black ground and binds. We then faced the Bavin measures, which seemed to pitch a little for 20 yards, and then ran level away to the back of the head." At the back of the head a 2-inch bore hole was put up for 128 feet, which passed through about 17 feet of Bavin, and then dark clod for the remainder of the distance, above which they struck the "red rock," when so much water followed that the hole was obliged to be plugged up immediately. A 2-inch bore hole was also put down here for 180 feet, passing through "Bavin measures the whole way, and finally ended in what we considered to be (as in the case of the hole in the jackey pit) the limestone. Shells were found in great abundance in the Bavin measures of this head."‡ After making these fruitless explorations in search of the Thick coal to the east of the shaft, they came back to it, and went up to a higher level, and followed a little 2-inch coal in No. 5 towards the west, and that shortly led them into the Thick coal.

Examining these facts by the light of the information gained in exploring the Baremoor colliery (see page 183) we shall, I think, have little doubt that the Thick coal is cut off at Westbromwich on its eastern side by a large "rock fault;" that beds of sandstone with fireclay and clunch come in, suddenly splitting up the Thick coal, and almost entirely occupying its place, and that the coal in No. 5, together with those numbered 8, 10, and 12, in the section (page 255) are all ends or detached parts of some of the beds of the Thick coal.

The general course of the boundary of this rock fault is nearly north and south, as it was found again, with Silurian shale beyond in the same heading, at the Lewisham pits near Virgin's End, one mile north of the Heath pits, likewise cutting out the Thick coal towards the east, and overhanging with a general inclination of about 22°.§ Similar facts with regard to the

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* By a jackey pit is meant a small occasional shaft sunk in any part of the underground workings for a particular and temporary purpose.

† I believe this hard rock was the one met with while the "Silurian System" was passing through the press, and which was supposed, from the description, to be trap by Sir R. Murchison. It probably, however, was the upper part of the Dudley limestone.

‡ MS. notes of the evidence given by the men who were engaged in these operations.

§ The general inclination of the sides of the rock fault at Baremoor colliery was much the same, varying from 18° to 25°.

ending of the Thick coal at a depth of 200 yards against some "rock and rig," were observed in some pits east of Lyndon near Hall End colliery, where there are no "red rocks" or Permian beds over the Coal-measures at all.

The most curious fact, however, is, that there is a sudden rise of the Silurian rocks both at the Heath and the Lewisham pits, through the Coal-measures; and this I am inclined to believe is not in consequence of any fault, but is due to their having formed an old Silurian bank of high ground during the Coal-measure period, and that the Coal-measures were deposited against that bank, its existence being favourable to the formation of sandstone and the accumulation of clay, but unfavourable to the formation of coal. The extension of this "rock fault" and old Silurian bank is at present uncertain; it appears, however, either that they extend continuously for three miles to the south of Westbromwich, or that they recur at that distance near Langley Green, as we shall see hereafter when describing the boundary faults.

We have in these facts, then, an instance of the unconformity of the Coal-measures both to the Silurian below and the Permian above; and it is probable that a little further east of the Heath pits the Coal-measures are entirely wanting, and the "red rocks" of the Permian formation rest directly on the shale or "bavin" of the Silurian formation. This would then be one of those cases where the denudation of the Coal-measures had proceeded the length of totally removing that entire series of rocks previously to the deposition of the Permian beds. The whole history of the Heath pits gives us a good example of the value of geological knowledge to the practical miner; 1st, assuring him of the general fact of the existence of coal beneath the "red rock" of the Permian and New red sandstone formations; 2nd, putting him on his guard as to the possibility of coming down to a spot where the coal had been removed by denudation, showing him what he might expect as *possible* as well as what was *probable*, and teaching him what to do in any case.

We have now to examine the original relations between the New red sandstone and the Permian. These two formations seem likewise to be unconformable to each other, but we cannot yet exactly ascertain either the amount or the precise method of this unconformability. The possibilities of the case are,—

1st. After the partial denudation of the Coal-measures the Permian rocks may have been deposited, not uniformly over the whole district, but in large patches here and there, filling up hollows, but leaving bare the higher spaces of older rock. On this surface the New red sandstone might be deposited, resting sometimes on the Permian, sometimes directly on the Coal-measures, or perhaps on still lower rocks.

2d. The Permian, after having filled up and levelled the old hollows in the Coal-measures, was continued as to its upper beds over the whole district. In that case those upper beds must have been again more or less denuded, as we now find the New red sandstone resting sometimes directly on the Coal-measures without the intervention of any Permian rock whatever.

This is the case at Brereton near Rugeley, where they have sank in several pits through the quartzose gravel or conglomerates of the New red down into the Coal-measures, the two lying distinctly in an unconformable position, the coals cropping gently up into the base of the New red.

After attaining the New red sandstone there appears no further occurrence of unconformability, the beds appearing to lie with perfect parallelism and regularity through the red sandstones and gypsiferous marls up to the Lias of Needwood Forest.

2. Actual and relative Position of the Rocks at the present day.

There are four distinct lines or areas of elevation in the district of the South Staffordshire coal field:—

A. An anticlinal ridge running about N.N.W. from Dudley nearly up to Sedgley Park School.

B. The broken anticlinal of the Lower Lickey running about N.N.W.

C. An anticlinal running N.N.E. from the Lye waste near Stourbridge to Netherton church.

D. A broad area of elevation, the general direction of which is about N.N.E., extending from Westbromwich old church to the Brown Hills on Cannock Chase.

It appears accordingly that the disturbing and elevating forces have acted along two principal lines of direction, running N.N.W. and N.N.E., crossing each other therefore, not at right angles, but at an angle of 45°.

A. The Dudley and Sedgley anticlinal is not a simple one, but very complex. There is one general broadish area of elevation which may be said to be defined by the outcrop of the Thick coal. Ranged, however, on this wider and gently-elevated region there are three smaller areas that have each suffered from

a maximum intensity of elevating force, namely, Dudley Castle Hill, the Wren's Nest, and the Sedgley district, including Hurst Hill. The axes of these three areas of maximum disturbance do not run parallel to the general axis of the elevated tract, but cross it very obliquely, running nearly true north and south. They would thus appear to be the result of the nearly equal action of the two prevailing lines of disturbing force before mentioned, as they run in a direction equidistant between them.

At Dudley Castle Hill the two bands of limestone rise boldly out on the south at angles varying from 25° to 30°, curve round with great symmetry and regularity on each side, and stretch off to the north in a narrow ridge, the sides of which dip east and west respectively from its central portion. As they run north the inclination of the beds increases to 50°, and the two pieces of lower limestone nearly meet each other on the crest of the ridge. On the east side the limestones begin at Shirts Mill to curve regularly round towards the north-west, dipping north-east, and then towards the west, dipping north at 10°, but are then suddenly cut off by a fault. The limestones on the west side are cut off by a fault opposite Shirts Mill, and in the gap between these two ends a piece of the upper limestone only is seen at the surface of the ground, dipping about west-south-west.

On the east side of the Castle Hill, between it and the Tipton road, the beds of limestone, after dipping from the hill for some distance, are found in the underground workings to flatten, and afterwards rise again towards the east, so that where the words "Castle-foot pottery" stand in the Ordnance map, east of the Tipton road, the limestone is reached by a shaft at the depth of only 52 yards (156 feet). From this point it again dips towards the east, at such an angle that in the space of 90 yards due east it becomes 112 yards deep (336 feet).*

The Wren's Nest Hill is similar in general structure to the Castle Hill, but differs from it in some of its details. Like the Castle Hill, its general form is that of an oblong dome-shaped elevation, with a central nucleus of lower shale, on which repose the limestones, dipping every way at considerable angles from the centre of the hill. On the south-west side of the hill the beds curve round very symmetrically, dipping west, south-west, and south, at an angle of about 40°. Similarly on the north-east side the two limestones are symmetrically curved, dipping east and north-east, and finally almost north at about 45°. Along the east and south-east sides of the hill, however, the inclination of the beds is much steeper, rising to 50°, 60°, and in one part upwards of 80°. At the south-east corner the beds, instead of bending regularly round, are broken through by a fault, so that the end of the upper limestone on the west of the fault is made to abut against the base of the

* This gives us a dip of 60 yards in 90 = 34°.

lower limestone on the east side of it. The lower limestone of the east side is itself cut off by the fault a little further south, but the upper limestone ranges some distance to the south alongside of the fault till, being finally traversed by it at a very oblique angle, it also disappears. The course of the fault towards the north may be traced a little way by the ending of the lower limestone on its west side, but it very likely runs up to the centre of the hill. From this spot a fault runs due east, cutting through the beds on that side of the hill, and shifting their outcrop 30 yards, so that the upper limestone on the south side of it is made very nearly to face the lower limestone on the north; from which it follows that this must be a very considerable downcast to the south, the beds north of it rising at an angle of 55°, those to the south at one of 80°. About 250 yards north of this another east and west fault cuts right across the ridge, fracturing the beds on the east side, and entirely cutting off those on the west.* From the centre of the ridge where it is traversed by this fault another is supposed to spring, running north-west, in order to account for the sudden ending of the two limestones in that direction as they curve round from the north-east side of the hill. Between these two last faults, on the north-west side of the ridge, a piece of the upper limestone only reaches the surface, just as a similar piece did between the two faults on the north-west end of the Castle Hill.

In the valley between the Wren's Nest and the Castle Hill repose the lower beds of the Coal-measures, the Bottom coal running some distance up it, both from the north and south ends of it.

Coal-measures likewise stretch between the Wren's Nest and the Sedgley Silurian district, but these are only the sandstones forming the base of the formation, and *they* lie only on the higher parts of the ground, the bottom of the valley north-west of the Wren's Nest showing Silurian shale at the surface.

The Sedgley tract is rather a complicated one. On the east side of it is Hurst Hill, where the Wenlock and Dudley limestones rise into a long oval anticlinal ridge, like those of the Wren's Nest and Castle Hill, but not so perfect. At the southern end the two limestones bend round and abut against the base of a piece of the upper limestone, a fault running between the two; this piece of the upper limestone must be cut off each way by faults, and a fault dropping down to the west runs along the whole of the remainder of that side of the ridge, preventing the appearance of the limestones. On the eastern side the beds strike north, dipping east at a high angle, are broken through by a small east and west fault just south

* It is worthy of remark that these faults in the Wren's nest and the other Silurian elevations do not appear to affect the Coal-measures, although it is clear that these dome-shaped elevations did not take place till after the Coal-measures were deposited. It is plain, therefore, that the cracks and fissures of the dome shaped elevations are strictly local, or have not much linear extension.

of the Cann Lane road, but from that spot strike still north till they curve round the northern end of the ridge, and dip in that direction.

They have been followed underground north of the hill for 200 or 300 yards, dipping generally north at about 30°, and ending towards the west against a fault which runs about north-north-west, and which must be a downcast to the west.

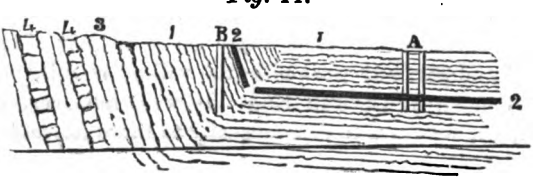
West of Hurst Hill is a rising ground formed of the Ludlow rocks, containing the band of limestone before described as the Aymestrey and Sedgley limestone. This at first dips west at an angle of 10° to 20°, forming a pretty bold escarpment, known as Sedgley Beacon Hill. The limestone, however, soon rises again to the west, and forms a cap to the high ground south of Sedgley, and after undulating a little in various directions, finally crops out on the west side of the hill, dipping east at 10°. North of Sedgley this cap does not appear, the Silurian beds forming a basin instead of a cap, and only cropping out on the west side of the Wolverhampton road, where they dip pretty regularly to the east at an angle of 20° for about half a mile. They then appear to curl over for a short space, and dip north-west at 35°, but I believe this is only a local flexure, and that the limestone beds curve round from this point to meet those of the Beacon Hill quarry. About one third of a mile north of that, however, the limestone again appears suddenly at the surface, dipping north-east at 60°, its northern end curving round till it dips north and north-north-west, at 15° and 20°, and then suddenly ending. The faults drawn on the map are the most obvious explanation of this peculiar position of the rocks, though with the exception of the one on the west side of Hurst Hill, they are all put in hypothetically. In the hollow of the Silurian rocks north of Sedgley the sandstones forming the base of the coal measures again occur, as shown on the map. About half a mile south of Sedgley the Silurian rocks are cut off by an east and west fault, a downcast to the south, which brings in the Coal-measure sandstone on their level. These lower sandstones spread over the ground from Upper Gornal, by Ellows Hall, to Lower Gornal, undulating in various directions, and at Turner's Hill, west of Lower Gornal, a patch of the Silurian with a band of Aymestrey limestone again makes its appearance from under them. There is, however, but one small quarry in it, and the exact details of the structure of the country just hereabouts are very obscure. Coal, supposed to be part of the Thick coal has been found and partially worked in the valley, running from the west side of Sedgley down by Cotwall End. It was, however, much broken and disturbed, but was said to dip generally to the west, and frequently at very high angles.

At Sedgley Hall farm a trial pit was sunk in 1828, in which they passed through 120 feet of "red croprash rock, and marl," under which were 200 feet of Coal-measures, and then the Thick coal dipping west at an angle of 12°. As there is no sign of the Thick coal cropping out between this spot and the Silurian ridge, there must be a fault between, which makes it probable that a fault forms the west boundary of the whole of the Sedgley Silurian district.

We will now briefly trace the outcrop of the coals round this singularly dislocated district of elevation. Beginning on the south of the town of Dudley, the Thick coal and the beds just above and below it crop regularly out, dipping south at an angle of about 25°. The crop of the Thick coal may be traced very easily, partly by the old, partly by the present workings across Dixon's Green, and a little north-west of the Freebodies to Burnt Tree, when it dips east at 30°, and thence curving round the Silurian tract of the Castle Hill to the angle between it and the Wren's Nest. Along the north-east flank of the Wren's Nest the Thick coal is nearly vertical, and was worked in an open quarry in the years 1849 and 1850.*

* As a good illustration of the very careless and ignorant manner in which the South Staffordshire coal field has been worked, I will describe the way in which this vertical piece of coal was discovered. A little to the east of it the Thick coal had been worked continuously in a nearly horizontal position at a depth of about 70 or 80 yards, as at A, fig. 11. The workings were continued towards the Wren's Nest till the coal ended against a fault or supposed fault, or at all events, some "troubled ground." A shaft, B, fig. 11, was then sunk from the surface, about 30 or 40 yards to the west of this supposed fault, in search of the coal. No notice could have been taken, in sinking this shaft, of the angle at which the beds inclined, and after being continued for more than 70 yards it was abandoned. In fact it must have been sunk the whole distance nearly along the same bed in which it was begun, the beds being nearly vertical, but that was not observed, or not understood, neither were the beds below the Thick coal recognized. The lease of the land was on the point of being given up by the gentleman who held it, when, a few feet of rubbish being accidentally removed from the surface at a particular spot, the coal was uncovered and of course worked. Even then, however, the ground bailiff, whom I met on the spot, and who had charge of all the mining operations, seemed scarcely to understand that this was merely a piece of the Thick coal bent up into a nearly vertical position, and broken off the horizontal portion below, as shown in diagram, fig. 11.

Fig. 11.



A. The old shafts.
B. The new shaft sunk in search of the coal.
1. Coal-measures.
2. The Thick coal.
3. Silurian shale.
4. The Limestones of the Wren's nest hill.

These men have a fixed idea *that coal grows*, that it is still growing and forming in the earth, and that not only the coals and ironstones grow, but

The coal strikes regularly from this spot to the Foxyards, where it flattens very rapidly to a nearly horizontal position.* It has been lately worked here also in an open quarry. Hence, after bending a little into the hollow between the Wren's Nest and Hurst Hill the crop of the thick coal runs along Ettingshall lane nearly up to Monmore Green.

A little south of Catchem's Corner it is broken through by the branches of the Great Lanesfield fault, which traverse likewise the lower beds to the west of it. Here, between Ettingshall Park farm and Monmore Green there is a very broken and disturbed district of Coal-measures. It appears that a rude anticlinal curve runs north from Hurst Hill by Ettingshall Park farm, the Parkfield furnace, and the Rough Hills colliery. The New Mine, Fireclay, and Bottom coals, after rising to the west, flatten, curve round, and dip again to the west; and a fault running north and south by the Wolverhampton furnaces, has a downcast to the west of about 150 feet, and brings in a good sized patch of the Thick coal in that direction, which dips north-west and west at an angle of 30° towards the red rock of the Permian formation. South of this, on the west side of the Parkfield colliery, the Coal-measures are completely smashed up by faults, and contorted in so violent a manner that, as I was informed by Mr. Smith of the Priory, one shaft passed through the Blue flats ironstone three several times, the beds being curved into the form of an S. It was quite impossible to represent on the very inefficient scale of the Ordnance map any thing at all approaching to the complicated faults and contortions of this piece of ground; but a few of the principal have been drawn with a tolerable approach to accuracy. They show that the action of the disturbing forces did not end merely in producing the Silurian elevations lately described, but was continued into the Coal measures to the northward, and may have extended still farther for an unknown distance, producing fractures and dislocations in rocks now buried under the Permian and New red sandstone rocks on the north-west.

Returning now to the south of Dudley, the outcrop of the Thick coal may be traced by the old workings along the south-west side of the town up to Shaver's End and Russell's Hall. It dips at a gentle angle to the south-west, not exceeding in any case 20°, and as the ground likewise slopes rapidly in that direction, the Thick coal does not at first acquire any great depth, and its outcrop is deeply waved and indented by the valleys and hollows of the surface.

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that the *faults grow likewise;* it is not possible, therefore, that they can have any clear ideas of their work, or be able to adapt it to any unusual circumstances.

* At the Foxyards a ground bailiff informed me that the Thick coal there was not the same as the Thick coal just mentioned, his only reason being that a parting of shale was a foot thicker in one place than in the other; he said there must be a fault between them on that account.

Thus, the little valley north of Russell's Hall completely cuts down through the Thick coal into the lower measures. As the ground on the opposite side of the valley however, called Dipdale Bank, rises to a sufficient height, it again brought in a large patch of Thick coal that extended nearly up to Gornal, where the ground slopes the other way. This piece of Thick coal being in no place more than 20 yards deep has long been worked out. On the south-west side of this indented outcrop* of coal runs the long Russell's Hall fault, which here throws down the Thick coal and other measures 120 feet to the south-west. Owing to the rise of the beds however, the Thick coal again crops out round Gornal Wood on the downthrow side of the fault.

The Russell's Hall fault running on the south-south-west side of the Sedgley and Dudley ridge is continued to the south-east along the south-west flank of the Rowley Hills. It holds its course very regularly towards the south-east, its "throw" increasing as we proceed to the southward, up to 150, 180, and 240 feet, and eventually near Rowley Regis it has a downthrow to the west of upwards of 400 feet. Beyond this its details are not accurately known, but at Coombs Wood it was partly proved by Mr. W. Mathews, and it seemed as if the fault were there passing into a very sharp anticlinal curve, as he found some Thick coal on the west side of it only 16 yards from the surface, and dipping at a high angle to the west, in which direction it acquires a depth of 750 feet in the space of a mile. On the east of the fault line it is known also to be 570 feet deep at a similar distance.

Near the foot of Mucklow Hill, a disturbance, probably due

* Mr. J. Kenyon Blackwell was kind enough to accompany me in tracing the crop of the Thick coal hereabouts, with his ground bailiff Mr. Waterfield. The outcrop of the coal was perfectly well marked by the occurrence, at the surface of the ground, of fragments of "shattery." This is the local name for a well-known indurated shale, streaked red and green, and baked almost into jasper. After extracting the coal, the fragments of coal and shale are piled up in the hollows that are left to afford a partial support to the roof. This mass of fragments is called "the gob," and in shallow excavations, where the air and water from the surface find ready access, it frequently takes fire, and burns for a very considerable time with a slow combustion. Just at the west entrance of the town of Dudley, in a cutting of the road, smoke and steam may often be seen in damp weather rising through the joints and cracks of a sandstone rock, from the combustion of the "Thick coal gob" below.

to this fault, may be seen in the coal measure sandstones, which dip 3° to the east on one side of it, and 30° or 40° to the south-west on the other. As the beds seem nearly, if not quite similar, it is probable that here also it is rather a rude anticlinal than a clean-cut fracture or fault.

B. The Lickey Hill anticlinal.—Now, if we follow the direction of the southern half of this fault, namely, about south-south-east, we shall strike in about 4 miles on the linear elevation of the Lickey quartz rock, which likewise has the character of a broken anticlinal. This fault, therefore, connects, if only in a vague way, the two elevated tracts of which the axes both run north-north-west and south-south-east, that, namely, of Sedgley and Dudley with that of the Lickey.

It is remarkable, that where the Sedgley and Dudley anticlinal ends, the mass of the erupted basalt of Rowley begins, and that hereabouts the Russell's Hall fault has its greatest amount of "throw," and is most of an actual fracture, while a mile south of the Rowley basalt it appears to be on the point of passing into an anticlinal ridge. This looks almost as if there would have been a continuous anticlinal elevation all the way from Sedgley to the south end of the Lickey, had it not been for the eruption of the Rowley rag. If the eruption of the Rowley basalt could be shown to have been subsequent to the formation of the whole Coal-measures, and contemporary with the fractures and dislocations of the coal-field, it might readily be accepted as a *vera causa* for the gap between the two anticlinals mentioned above. We should then suppose that the strain acting on the beds was relieved at one point by the actual outburst of trap, while in others it resulted in the uplifting and protrusion of the inferior rocks.

What may be the position of the Coal-measures below the Permian beds of Frankley Hill we of course have no means of ascertaining; but on the south side of that ridge a few Coal-measures with a little coal showed themselves, on each side of the quartz range of the Lickey, in a nearly horizontal position. These beds may stretch continuously and horizontally under the Permian, from the valley south of Halesowen, and become exposed at the Lickey by simple denudation, in which case they

are probably very high Coal-measures, or they may be the lowest Coal-measures brought up either by the rise of the beds or by dislocations concealed under Frankley Hill.

The quartz rock of the Lickey is greatly broken and fractured, and in some cases violently contorted. At the northern end, about Holly and Rubury Hills, and by the New Road, it dips easterly at from 10° to 20°. Near the old Rose and Crown it dips west at 35°. In the quarry opposite the Reservoir it is violently contorted. At the south end limestone was formerly got, and there seem to be some softer shaly beds thereabout. South of Kendal End, at the extreme southern nose of the ridge is a boss of a dark trap rock, a kind of greenstone. It is believed that the eastern boundary of the quartz ridge south of the Colmers is a fault throwing down to the east. North of the Colmers soft shaly beds, with calcareous bands and Silurian fossils, have been got on each side of the ridge, just underlying the Coal-measures.

We will now examine the two other areas of elevation, namely, *C.*, the Netherton anticlinal, and *D.*, the Walsall district.

C. The Netherton anticlinal.—A little east of the village called the Lye, near Stourbridge, is found a protruding mass of Ludlow shale, with a band of limestone, the same as that before noticed at Turner's Hill and Sedgley. It dips east at 40°, but after running north of the road for almost a quarter of a mile, it suddenly ends, being probably cut off by a fault. Immediately south of the road it terminates in a similar way.

In the cutting of the road the Silurian shale may be seen dipping east at 40° for about 30 yards above the limestone; there are then 9 yards of Coal-measure sandstone, with ironstone balls, dipping in the same way, and 100 yards east of that the bottom beds of the Thick coal may be seen dipping west at 65°. This Thick coal must, therefore, be reversed, or bottom upwards. In the Hays coal pits, just east of this, the Thick coal is found greatly broken and disturbed, dipping generally east, at a high angle, and then suddenly assuming a nearly horizontal position, in which it continues some hundred yards to the eastward.*

* In one shaft the Thick coal was actually bent over near the outcrop, so that the same vertical pit passed twice through the Thick coal.

From the Hays the crop of the Thick coal may be traced about a quarter of a mile to the south-south-west, when it is entirely lost. On the other side of the Lye the Thick coal comes in again dipping west, and on this side the outcrop of the coal may be traced some distance to the south-west, when it suddenly ends. South of these two ends nothing but upper Coal-measure sandstone can be seen, almost all in a horizontal position. It is, therefore, supposed that the anticlinal is here cut off by a fault which would run about east-north-east and west-south-west.

From the Lye to Netherton Church the anticlinal runs in a remarkably regular manner, the Thick coal dipping on either hand at an angle of about 20° or 25°, and its outcrop quite easily traceable by the old workings. Just north of Netherton Church the anticlinal dies away, the two outcrops meet, and the Thick coal dips north till it flattens and rises again towards Dudley.

In the centre of this anticlinal, in the canal tunnel and cutting near Yew Tree Hill, is exposed a remarkable mass of basalt or greenstone, which sends out veins into the adjacent Coal-measure sandstone, and is therefore intrusive. It is not at all necessary, however, to look upon the intrusion of this mass of trap as contemporaneous with the formation of the anticlinal elevation.

D. The elevated district of Walsall.—It will be recollected that we connected the two first areas of elevation; those running from south-south-east to north-north-west by a line of fault or dislocation, occupying a good part of the intermediate space, and pointing directly from one to the other.

It is singular that we are in the same way able in a great measure to connect the two elevated districts *C.* and *D.*, the strike of which is from south-south-west to north-north-east.

It is true that the anticlinal running from the Lye dies out and disappears at Netherton, and that for a space of at least a mile and a half there is little or no indication of any disturbing force having produced any impression in the line of its direction. On the contrary, the only dislocation in this space (the Russell's Hall fault) is one that runs directly across that line. Having traversed that space, however, we again come on a very remarkable dislocation, almost precisely in the line of the Netherton anticlinal. This is the dislocation known as the Dudley Port

Trough fault, which, starting from the outskirts of the town of Dudley, and the north point of the Rowley trap, runs nearly due north-north-east for more than two miles, when, being met by another dislocation, it turns off to the north-east and east, and finally disappears in the direction of Westbromwich old church.

Now from Westbromwich old church to Wednesbury the strike of the beds and the direction of their outcrops (although they are much shifted by various faults) is almost due north-north-east. Proceeding in that direction we get the Silurian district of Walsall rising to the surface, with its associated limestone beds likewise striking north-north-east; and still further north we get the outcrop of the Brown Hills coals running north-north-east over a space of three miles. In spite of its broken and interrupted character then, we have here a south-south-west and north-north-east strike prevailing for 10 miles; and if we look at the general shape of the whole coal-field, we shall see that its greatest linear extension is likewise in a south-south-west and north-north-east direction from Stourbridge to Rugeley. Hence we begin to perceive that a south-south-west and north-north-east strike is really the true dominant strike of the district, the direction in which the elevatory forces, to which the presence of the coal-field at the surface is due, have most largely acted; and that the south-south-east and north-north-west range running from the Lickey to Sedgley, though showing the most conspicuous features, and giving examples of the greatest local intensity of disturbance, is itself but a local and secondary* line of elevation, an exceptional interruption to the prevailing structure of the coal-field.

The Walsall Silurian district is of very irregular shape, owing partly to the action of several faults, partly to the overlapping of the coal measures. In the cutting of the South Staffordshire railway on the west of the town may be seen the calcareous beds of the upper or little limestone. They dip west at an angle of 5°, and in that direction the Silurian shale becomes

* I by no means intend to represent it as secondary in point of time. We may suppose the two forces to have been contemporaneous, that acting in a north-north-west direction to have been a linear one, that having the north-north-east direction to have affected the whole area.

shortly covered by the lower Coal-measures containing the Blue flats and other ironstones. On the north of the town, and east of the Lichfield road, are some large old quarries, in which the lower or thick limestone was formerly worked, dipping westerly at 10°. This limestone must be continued under the town to the southward, being concealed from view by a very thick capping of quartzose gravel of the drift period. Just south of the town it must be cut off by the fault which runs east and west from the south side of "the Moat." This fault is known in the Coal-measures to have a downthrow to the south of 120 feet. Its extension to the east is partly hypothetical, as from Walsall race-course no rock is seen at the surface either southward or eastward for at least a mile and a half.

In tracing the Thick limestone to the north it is seen to bend round and to be cut off by a small fault, a downthrow to the north, near "the Butts." Partly by reason of this downthrow, partly from the rise of the ground, the lower Coal-measures with the Blue flats ironstone here overlap the limestone, and run some distance to the east of its outcrop, till the gradual fall of the ground allows the Silurian shale to come to the surface again.

Near Rushall Castle is another little fault throwing down to the north, but here the Thick limestone again crops to the surface, in consequence of the denudation of the Coal-measures, and has been worked in quarries towards the north-east as far as Linley. In some of the quarries between Rushall Castle and the Halfway House the Coal-measures may be seen on the west side of the excavations resting on the Silurian shale; but the Coal-measure boundary shortly strikes north, while the Silurians strike north-west, in consequence of which at Daw End the Upper or Little limestone comes out from under the Coal-measures, and may be traced by a line of old quarries running in a curved line down towards Ketton's garden. In the canal near here a small supplementary band of limestone is found between the two limestones, and towards the Halfway House a short band of limestone was worked below the Thick limestone. These masses are called "Self lumps;" they are large lenticular masses, in which the calcareous so far prevails over the argillaceous matter as to form good workable limestone.* North and east of Daw End the Silurian rocks are altogether cut off by a great fault, which we may call the Daw End and Linley fault, running north-west and south-east, throwing down to the north east and bringing in the Coal-measures in that direction. In this Coal-measure tract was sunk the Trial pit at Aldridge (see Vertical sections, sheet 16, No. 4), and another pit between Aldridge Lodge and Hill End.

This latter pit, I was informed by Mr. Roberts of the Butts, was 62 yards deep, and that three measures of coal and two of ironstone were passed through, the whole dipping east-south-east at an angle of 25°.

Starting from the Walsall and Daw End limestones, and traversing the ground to the east, we find here and there small openings or cuttings in

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* It must be borne in mind that all the Silurian shale near these lime stones is more or less calcareous, and full of calcareous lumps and nodules.

the shale below them, but we do not get much information till we come to the banks of the new canal running from Longwood Wharf south-south-west by Ginity Graves and the Bell to the Tame Valley canal by Bustleholme Mill and Ray Hall. All down this canal are cuttings in Silurian shale or "bavin," for the most part as nearly horizontal as possible.* East of it, about Hay Head, we get another limestone rising from underneath this shale at an angle of about 10°, running from the fault near Aldridge Lodge down to Daffodilly, where it begins to curve and dip at a high angle, finally ending against the "red rock" near the Skip, its last piece dipping south-west at 35°. East of this, which is locally known as the Barr limestone, nothing is seen till we come to the "red rock;" but as near Hay Head there is a space of one third of a mile between the two, we ought, if this Barr limestone be truly the representative of the Woolhope limestone, to get the upper part of the Caradoc sandstone series in the intermediate space. The ground is absolutely flat, and rather wet and marshy, and apparently covered by drift clay, so that in the absence of deep excavations this point cannot be settled.

It is possible that the fault before mentioned, which strikes east and west from the Moat, and is supposed to cut off the limestones south of Walsall, is continued to the east, and likewise cuts off the south end of the Barr limestone.

No limestone is known, either by natural outcrop or by sinkings, south of this line. The Silurian shale, however, is seen at intervals, not only in the canal before mentioned but at other points, and was formerly exposed in the cutting of the London and North-western Railway south of Tame bridge. In a horsepond at the Goodwin farmhouse considerable nodules of limestone were got out in the year 1849, rendering probable the near neighbourhood of one of the bands of limestone to this spot. On Delves Green are many old pits in the lower Coal-measures, from which the Blue flats ironstone had formerly been got, and one of these had been sunk as a trial pit to the depth of 50 yards, chiefly, as appeared from the "spoil" on the pit bank, in Silurian shale. Near the seventh milestone on the Walsall and Birmingham road an outlyer of Coal-measures, with sandstone and ironstone, was cut through on the top of the high ground there, making it probable that the whole of this piece of Silurian shale south of the outcrop of the limestones would have been covered by a mask of Coal-measures, had the ground been a little higher and the rocks not worn down by denudation to their present level.

That the Silurian shale continues under the coal-field to the westward of the district now described, dipping gently and equably towards the west, is shown by the following facts.

* In cutting this canal a number of fine fossils were discovered, especially heads of Hypanthocrinites and Echinoencrinus, also many fine and rare brachiopods.

On the west side of Friar Park wood a shaft was sunk in 1849, in the first 60 feet of which one or two small coals were found, under which were some ironstones, and below them Silurian shale, in which the sinking was continued to a depth of 150 feet from the surface.*

At Hobbs Hole, a little east of Darlaston, Mr. Smallman gave me the following abstract of a pit sunk there:—

	FT.	IN.		
From surface to bottom of Heathen coal -	15	0	307	6
From that to bottom of Coal-measures -	292	6		
Limestone shale - - - - -	60	0		
Thin limestone - - - -	16	6		
Limestone shale - - -	90	0		
Thick limestone - - - -	30	0		
	504	0		

At Bentley, south of Pouk Hill, the Silurian shale was about 160 feet deep, and the Thin limestone 373. In the Chillington colliery near Wolverhampton they reached Silurian shale at a depth of 580 feet, and passed through shale and thin bands of limestone for more than 200 feet additional.

In addition to the above places where the Silurian rocks have been reached through the Coal-measures, we have at Deepfields the top of the Silurian shale 680 feet, and the top of the limestone 850 feet deep; at Dudley Port Silurian shale at a depth of 550 feet, the limestone at 620 feet; at the pits at Langley Green, south of Oldbury, a considerable thickness of Silurian shale passed through in a pit not more than 390 feet deep; and the same rock but a little way below the Thick coal at Westbromwich Heath pits.

If we look at these facts, together with that of the protrusion of Silurian rocks at Turner's Hill, the Hayes near the Lye Waste, and the Lickey, we are led irresistibly to the conclusion that a great floor of Silurian rocks stretches immediately under the comparatively thin covering of Coal-measures throughout all the coal-field south of Bloxwich at all events.

Having thus described the foundation of the coal field, and the principal lines and areas over which that foundation has been lifted up, or nearly up, to the surface, we must now examine a little more in detail the structure of the productive part of the coal-field itself.

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* This was being done for Lord Dartmouth. I did not see the person who advised the sinking, but the man in charge on the bank was not aware that it was the "limestone shale" or "bavin" they were bringing up, although it was crowded with fossils, and had even nodules of limestone in it; and he told me *they were trying then for coal underneath it.*

For this purpose we may consider the coal-field divided into three parts; namely, the south-western portion, the central, and the northern.

The south-western will be all that part south and west of the ridge running through Sedgley, Dudley, and Rowley; the central all between that ridge and the great Bentley fault; the northern all north of that fault.

The south-western portion.—We have already examined the outcrop of the Coal-measures along the south-west side of the Sedgley and Dudley ridge, and their sudden depression to the south-west by the downthrow of the Russells Hall fault, as also their subsequent re-elevation and outcrop along the flanks of the Netherton anticlinal. This latter feature subdivides the south-west portion into two imperfect basins, one of which might be called the Pensnett basin, the other the Cradley basin. At the south end of the Pensnett basin, between Stourbridge and the Lye, the Thick coal crops out, the beds dipping north, and being affected by one or two gentle flexures, which, together with the undulations of the surface of the ground, cause the line of the outcrop to assume the indented undulating form it has in the map. A few east and west faults, with a downthrow to the south of a few yards each, traverse this part. At Brierly Hill, two east and west faults form a trough, each having a downthrow of 80 or 90 yards, about 250 feet, in the centre of their range, but decreasing that amount towards their extremities to less than 30 yards, or 90 feet. The southern of these two faults ends on the west flank of the Netherton anticlinal, but the northern one is said to run right across it, carrying a downthrow to the south of 10 or 12 yards, and to run in a curved line to Withymere, where it dies out on coalescing with the Russell's Hall fault.

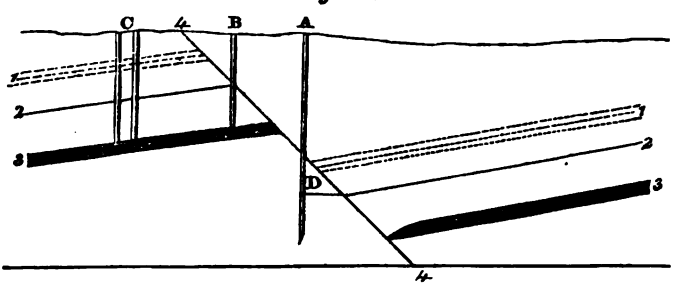
On the west both these faults are cut off by the southern end of the Brockmoor fault, which, springing out of the western boundary fault north of Brettell Lane, runs about north-north-east to Pensnett reservoir, having a downthrow to the west of about 300 feet. This fault sends out two slight branches, one to the east by the Round Oak, with a downthrow to the south of 5 yards; one to the north-east through Hart's Hill, a downthrow to the south of 10 or 8 yards. At Pensnett reservoir the Brockmoor fault is believed to branch as shown in the map.

I was informed by Mr. Pearson of Brierly Hill, that "at Brockmoor this fault threw down to the west 130 yards, or nearly 400 feet, that it was only *a slip*, but was 200 yards wide, or made that much barren ground." The meaning of which description is, that although the fault itself had no apparent thickness, yet the two ends of the Thick coal were separated by 200 yards measured on the surface of the ground, showing the fault to have an inclination of not more than 33°.

The Corbyn's Hall fault strikes out of the Great Boundary fault about a mile north of Bugpool, a little west of Salter's Hall. Its downthrow is

likewise to the west and north, at first 360 feet, diminishing then to 300, which it maintains for upwards of a mile. It then curves gradually round to the north-east by Shut End House, diminishing its throw to 240 feet, and thence passing through the north end of Barrow Hill by Hunt's Mill, it strikes east up to Russell's Hall iron furnaces, its downthrow being north 120 feet. I believe this is the fault mentioned by Sir R. Murchison in the Silurian System, p. 504. He gives a section of it on the authority of my friend Mr. W. Mathews, in which there is an actual dyke drawn, 140 yards in width, between the broken ends of the coal. Mr. Mathews derived his information from his ground bailiff of that time, but on cross-questioning his present ground bailiff, Mr. Job Taylor, I arrived at a different and more natural explanation of the facts. I may premise, that in South Staffordshire, by the "width" of a fault is always understood *the width measured at the surface of the ground*, between the broken ends of the Thick coal, or any other bed that may be worked. It is the space of barren ground as to that particular bed, measured in roods or acres on the mining plan. It depends, therefore, not on the actual or real width of the fault, but solely on the angle of its inclination. This will be seen from the following account: – Job Taylor first assured me that this was not *a fault* at all, but only *a slip*, by which he meant that there was no real width or substance in the fault. He then told me that the "throw" of the fault was 90 yards, and its "width" was exactly the same, as in the following diagram:—

Fig. 12.



Scale, 1 inch = 150 yards.

A, B. C. Shafts.
D. Gateroad.
1. Beds containing water.
2. Brooch coal.
3. Thick coal.
4. The fault.

A shaft (A in the diagram) was sunk, which crossed the fault between the ends of the pieces of Thick coal, and was therefore said to be sunk in the fault. But from this shaft they drove out a gate-road (D), and on the deep side they hit the Brooch coal *in advance* of the Thick coal, as in the diagram. Moreover, there were certain wet beds (1 in diagram), beds from which water came out, above the Brooch coal. Now, in a shaft (B) sunk to the Thick coal on the crop side of the fault, these beds were not passed through, and the shaft was quite dry; while in the shafts (C) further from

the fault, they were met with, and the shafts were quite wet. This likewise agrees with the diagram, and the facts are explicable only on the supposition of its correctness. Job Taylor likewise assured me that on the deep side of the fault the coal was "pinched" towards the fault by the descent of the roof, as in the diagram.

A little north-west of the commencement of the Corbyn's Hall fault, two parallel faults strike nearly north from the Boundary fault, one throwing down to the west about 300 feet, another up to the west 150 feet, with a complicated and broken piece of ground between them. They coalesce or come very near together, just south of the Dudley and Kingswinford turnpike road, and thence proceed as one fault north-by-east, just west of the Shut End furnaces, with a total downthrow to the west of 180 feet. This fault, called the Shut End fault, is believed to run by Askew bridge up to the Russell's Hall fault there. It sends a considerable branch from Shut End by Cooper's bank, nearly to the Graveyards, which has a downthrow to south-east of about 120 feet. Even at Shut End this fault is not a single fissure, like the Corbyn's Hall fault, but a wide dislocation made up of a number of steps or smaller fractures (see Horizontal sections, sheet 25, No. 7). Mr. Colly, the ground bailiff, was kind enough to give me the details of a gate-road that was driven through the fault, starting from the Thick coal on the "crop" side of it, *i.e.*, the upcast side. The gate-road was horizontal, but they met, in driving, with beds lying at various angles, of which the following are the details:—

	FT.	IN.
1. Coal and batt	9	0
2. Rock binds	42	0
3. Rock	12	0
4. Peldon	21	0
5. Rock binds	33	0
6. Pin measures	12	0
7. Herring coal	6	0
8. Bind measures	9	0
9. Brooch coal	34	6
Carried forward	178	6

	FT.	IN.
Brought forward	178	6
10. Rock binds	8	0
11. Herring coal	9	0
12. Bind measures	9	0
13. Brooch coal	9	0
14. Fire clay	9	0
15. Two foot coal	6	0
16. Red ground	33	0
	261	0

This red ground No. 16 was outside of the faulty ground, and at the end of the 33 feet they sank a "jackey pit," and found the Two-foot coal which they had just previously passed through lying horizontally 22 feet below them. The whole length of the gate-road was 261 feet, during which they twice passed along the same set of beds, rendering it probable that there was an upcast between the downcast faults. Had the dip of the several fragments of beds been given, we might have constructed a very instructive section of this gate-road.

The other smaller faults of the Pensnett basin will be sufficiently understood by consulting the map.

Between Netherton and Dudley the two basins of Pensnett and Cradley

coalesce, the coals and the principal dislocation,—the Russell's Hall fault,—ranging uninterruptedly from one to the other. With the exception of that side of the Cradley basin, where the beds rise suddenly to the Netherton anticlinal, the measures have a general uniform and gentle dip to the south, with but very few faults or dislocations. There are a few faults near the Baremoor colliery, and at Corngreaves, which may be understood by reference to the map. The others, with the "rock fault" at Baremoor, have already been sufficiently described. We have likewise already (see p. 165) had occasion to allude to the general dip of the measures from Hawne to Halesowen, by which it was shown that the beds of sandstone that stretch horizontally from Halesowen to Wassel Grove and the country near Wychbury Hill, must be about 1,000 feet above the level of the Thick coal. Inasmuch, however, as near Wollescote and Prescott these beds are found almost on a level with the outcrops of the Thick coal that strike along the south end of the Netherton anticlinal, it is clear there must be a large fault, having a great downthrow to the south between the two. This is marked as a supposed fault on the map by a dotted or broken line running from Prescott to the east-north-east. It probably dies out and ends before reaching Cradley, as no such fault has been found in the workings about Corngreaves, and the dip of the beds will there account for the depth of the coal to the southward without its agency.

On the road from Halesowen to Hagley two considerable patches of Permian rock are seen to rest on the upper sandstones of the Coal-measures; one at Quarry Hill and Hasbury, and the other at Hayley Green. These Permian beds dip to the southward; but in the brook immediately south of them good Coal-measure beds can be seen, and further south in Uffmoor Wood one, if not two, little coals have been found, and may be seen cropping into the brooks. It is clear, therefore, that these two Permian outliers are cut off to the southward by a fault which is an upcast to the south, and runs about east-north-east and west-south-west along their southern boundary.

The southern boundary of the coal-field stretching from Wychbury Hill on the west, to Lappal Tunnel on the east, is formed by the horizontal beds of the upper Coal-measure sandstones and shales becoming covered as we ascend the rising ground to the south, by the horizontal beds of the Permian rocks.* It will be seen accordingly, by inspection of the map, that this boundary, instead of being smooth and regular, like

* By horizontal is here meant "apparent horizontality" only. There may be a slight dip to the southward of 2° or 3°, every geologist knowing that it is impossible to detect such a slight variation from horizontality with anything approaching to certainty or accuracy, except under very favourable circumstances.

that of the east and west sides of the coal-field, is indented and undulating, depending chiefly on the shape of the ground. Wherever a valley sufficiently deep penetrates to the south, there is a bay of Coal-measures marked in the map. Wherever a ridge sufficiently high stretches to the north, a promontory of red rock will be seen advancing in that direction. We have here, therefore, a true natural surface boundary of the coal-field, caused simply by the denudation of the rock that covers it along a certain curved line, and the consequent exposure of its upper measures at the surface of the ground.

From the Lappal Tunnel it will be seen, by reference to the map, that a curious little narrow strip of Coal-measures runs out two miles to the east, as far as the Stone House near Harborne. The existence of Coal-measures at the surface along this strip is shown partly by the rubbish got out of the shafts of the tunnel near Wilderness Farm, but principally by a pit sunk by Mr. Flavel, between the Stone House and Bog Meadow Coppice. From this pit, which was 80 yards deep, nothing but Coal-measure shales and "binds," with small ironstone nodules, was extracted. The measures dipped north at about 10°, and they may possibly have dipped regularly under the Permian and New red sandstone rocks which stretch from Harborne to the Quinton, though it is much more likely that the boundary between them is a fault. On the south side of the ridge, at all events, the boundary must certainly be a fault, as near the Stone House brick red sandstone may be seen dipping south at 10°; flattening to 5° at the quarry beyond Weoley Castle.

West of the Quinton we come again upon the Coal-measures that stretch in apparently nearly horizontal beds all round the Leasowes, and thence to the north towards Rowley and Oldbury. We have already described the sinking at Blackheath, and the debased condition of the Thick coal there, and mentioned the "rock faults" and other accidents affecting it near Titford Reservoir. North of that it lies with great regularity and nearly horizontally up to the neighbourhood of Oldbury. The gate-roads of the Grace Mary Colliery, near Lye Cross farm, have been driven 100 yards under the Rowley rag without meeting with more interruptions from it than they found

outside of it, and which have already been mentioned (p. 242). This point may be considered the extreme southern end of the central district of the coal-field which we will now proceed to examine, taking, in the first instance, the Thick coal as our guide in tracing out its structure.

The central portion.—On the flanks of the Rowley Hills, which form the southern boundary of the central district, the Thick coal has a depth below the surface varying from 100 to 200 yards, according to the variations in the surface of the ground, the dip of the measures and the dislocations affecting them. On the east, towards Oldbury and Westbromwich, it is thrown down by the eastern boundary fault to a still greater depth, and the Coal-measures are concealed under the "red rock" of the Permian formation. Over all the country round Tipton, Great Bridge, Hocker Hill, and Coseley, the Thick coal still preserves the same depth of from 100 to 200 yards, in spite or in consequence of the many faults which traverse it. Outside that space of ground, however, the Thick coal rises to the surface on the west, north, and east sides. We have already examined its western outcrop when describing the Sedgley and Dudley anticlinal ridge. From the northern end of this, or from Ettingshall Lane near Wolverhampton, the outcrop of the Thick coal runs nearly due east, a little north of Bilston up to Darlaston. Over all that space, the measures have a very gentle rise to the north, or, in other words, an equally slight dip to the south. The Thick coal dips so gently to the south, that until it meets the Lanesfield fault, it is never more than 40 yards deep, so that in all that space it never becomes covered by the Broach coal, which is more than 40 yards above it. The lower beds rise so gently to the north, that the outcrop of the Heathen coal, only 15 yards below the Thick, spreads sometimes a quarter, or even half a mile to the north of it. The New Mine coal, about 56 yards (170 feet) below the Thick coal, ranges 2 miles to the northward of it before it reaches the surface and crops out. The Fire-clay and Bottom coals stretch still further north up to the Bentley fault itself, and only crop out to the eastward, one on each side of the trappean boss of Pouk Hill and the bed of trap below it. From this point the outcrops of the Fire-clay and Bottom coals run south till they meet the Moat fault, which being a downcast to the south of 40 yards, throws their outcrops some distance further east, still ranging south, till they meet the Darlaston fault.

This Darlaston fault being a downthrow to the south of from 9 to 22 yards, cuts the outcrop of the Thick coal in the town of Darlaston, and from this point southward the Thick coal and the rest of the measures all rise to the east, their outcrops being successively cut off and thrown eastward as they come to the succession of faults that traverse them, as shown in the map.

One of these faults, a little south of Wednesbury, has in part of its course a downthrow to the south of 140 yards (420 feet), and it throws

the outcrop of the Thick coal more than a mile to the eastward, or from near Wednesbury bridge to Stone Cross (see map).

This outcrop can be traced from Stone Cross to the south-south west as far as Hall End, when it is again broken through by a fault, south of which it does not reach the surface at all, as it either ends at a great depth against a "rock fault," or is concealed by the Permian rocks of West-bromwich.

We have now to trace the faults affecting this central district. We have already mentioned the Dudley Port Trough faults. These are two parallel faults starting from near the Free bodies at the north-west corner of the Rowley Hills, and running about north-north-east for about 2 miles up to the Horsley collieries. They are scarcely a quarter of a mile asunder, and each throws down the piece of ground between them to the depth of 130 yards; that is, the piece of Thick coal between them is 130 yards (or 390 feet) deeper than that on either side.

It has been proved by the workings that each of these faults hades, or slopes downwards, towards the other at an angle of about 75°, they must, therefore, meet at no great distance below the included piece of coal, and as their throw is equal and opposite, they must, where they meet, exactly counterbalance and neutralize each other, and if continued at all, must descend as a mere fissure or crack, without producing any dislocation. It so happens that the included piece of coal is, at Dudley Port, exactly on a level with the Dudley limestones outside the faults, and the workings have been continued from the coal into the limestone. This likewise shows that as regards the mass of the country on each side, these Dudley Port Trough faults (or fault) are no dislocation at all, but only so as regards the piece of ground between them. Nevertheless, it is probable that they mark the line of most intense strain at the period when the elevatory forces were acting on the district. This is a point which for convenience sake we will discuss more fully farther on.

That they had the effect of materially modifying the action of the disturbing force is shown by the fact that to the southward of the Dudley Port Trough all the faults are downthrows to the north, while to the northward of it all the faults are downthrows to the south; in other words, all the faults of the central district form a succession of steps down to the Dudley Port Trough faults.

Starting from Round's Green, between Timmin's Hill and Oldbury, we have 4 faults, with some branches, running about north-east and south-west, and throwing down to the north-west from 90 to nearly 180 feet. The course of these faults is concealed towards the south-west by the trap of the Rowley Hills, while towards the north-east they appear to die out, or at all events have not been traced. The southern fault of the Dudley Port Trough itself dies out towards the north-east, its throw diminishing to 210 feet near Horsley, where it has a small branch throwing down *to the south* 90 feet. Two small faults, with a southern downthrow, likewise start out of it near Roseland farm.

The northern fault of the Dudley Port Trough runs into and coalesces with the Tipton fault near Horsley.

North of the Dudley Port Trough we have 7 principal faults all running nearly east and west, and all having a downthrow to the south. These are—

1. The Tipton and Hilltop fault.—This has a branch running from Tipton to the south-west, and throwing down 54 feet to the north-west; but its main line at Tipton Green throws down 45 feet to the south, and thence it runs about east-by-north to Hilltop, having a maximum throw of 150 feet near the Eagle furnace, whence it diminishes in amount towards Westbromwich old church to 20 feet and less.

2. The Bald's Hill fault, which, just north of Mr. Davis' Crook Hay furnaces near Hateley Heath, has a downthrow to the south of 420 feet. This fault runs east as far as Stone Cross, beyond which its course has never been proved.* To the west of Bald's Hill this fault splits into two branches, the southern of which runs through Gold's Green with a downthrow to the south of 96 feet; the other runs through Hocker Hill, its downthrow diminishing from 120 to 90, and finally to 25 feet, as it runs west.

3. The Coseley and Wednesbury fault, which in its central part has a downthrow varying from 150 to 210 feet. To the westward it splits into two, each having a downthrow of 45 and 66 feet respectively, and then diminishing to nothing. On the south side of the town of Wednesbury its throw is 90 or 105 feet, whence it runs towards Crank Hall, and probably dies out.

4. The Lanesfield fault, which has a downthrow of 180 or 210 feet, near Hallfield, diminishing in each direction, and finally dying out. Towards the west this fault splits into two well marked branches, which have a throw at first of 105 and 66 feet respectively, the southern branch diminishing very regularly from 105 to 30 and 20 feet, the northern being cut off by one of those faults mentioned before as being very numerous and complicated in the corner of the coal-field north of the Sedgley ridge, and marking the prolongation of its disturbing power.

5. The King's Hill fault is a very slight one, having a throw of not more than 20 to 25 feet.

6. The Darlaston fault has just east of Darlaston a downthrow of 66 feet. It is not known east of that, but it may possibly run along the north side of Delve's Green, where the Coal-measures stretch eastward over the Silurian shale. To the west it splits half a mile from Darlaston, its branches diminishing to 27 and 9 feet respectively, and shortly disappearing.

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* The country here is very much covered by drift. Mr. Yardley, of Tipton Moat, informed me that at Mr. Bagnall's Moorland colliery, near Hateley Heath, it was at one pit 165 feet to the top of the Thick coal, over which there were only 51 feet of "rock binds," &c. for a roof; all the rest, or 114 feet, being drift sand and gravel.

7. The Moat fault mentioned before as running south of Walsall.—It has a downthrow of 120 feet just south of the Moat, but nothing more is known respecting it.

Several other small faults may be seen marked on the map, not worth a more detailed description.

The northern portion.—The northern portion of the coal-field is the part betwen the Great Bentley fault and Brereton. None of the faults we have hitherto been examining, with the exception perhaps of the Russell's Hall fault, exercise any marked influence on any large portion of the country. They merely traverse the beds for a certain small distance, and alter their levels over a certain limited space, the amount of the alteration soon diminishing to nothing. If either of these faults did not exist, there would rarely be any material change in the nature or character of the rocks of the locality.

With the Great Bentley fault, however, the case is different.

We have seen that between Wolverhampton and Walsall the Coal-measures cropped gradually, but steadily, to the north, so that, first the Thick coal, then the Heathen, then the New mine, rose to the surface of the ground and ended towards the north. The Fire-clay and Bottom coals were but a few yards deep; and it is clear that if this gradual rise of the measures to the north had continued uninterruptedly for a comparatively short distance further, the very base of the Coal-measures would have come up to the surface of the ground, and the Silurian shales and limestones would then have cropped out beyond, spreading north perhaps for many miles. Cannock Chase would in that case have been a Silurian instead of a Coal-measure country.

The great dislocation of the Bentley fault, however, throwing down to the north to the amount of 120 yards (360 feet), brings in the Coal-measures even up to the base of the Thick coal, and that formation then spreads up to the north, forming the surface of the ground, till it is concealed under the New red sandstone.

About a quarter of a mile north of the Great Bentley fault another runs parallel to it, throwing down to the south 25 yards, and to that extent forming a trough, or neutralizing the effect of the northern downthrow; still, however, leaving nearly 100 yards of downthrow to benefit the country to the north.

Between these two faults, on the south side of Bentley Heath, they get a 9 foot coal, called the Old Man's coal, which crops out shortly in each direction, as it is never more than 5 or 6 yards deep. The Bentley Hey coal, 5 foot thick, is 50 feet under this; and the Heathen coal, 50 feet under the Bentley Hey. We have already seen that the Old Man's and the Bentley Hey coals must, if even only on account of their relation to the Heathen coal, be the bottom beds of the Thick coal separated into two. North of the 25 yards upcast fault, these two coals, the Bentley Hey and the Heathen coal, are still found in part of the ground, though very near the surface. The Bentley Hey coal crops very shortly, the line of its outcrop running north of Lane Head, and thence towards the New Invention. Owing to several small faults, however, as also to several small undulations of the beds, it was found impossible to trace its outcrop with any degree of accuracy on the small scale of the one inch map. The crop of the Heathen coal ran more nearly north-west up to Bentley farm, but the same difficulty, owing to the wretchedly small scale of the map, was again met with, and the attempt finally abandoned.* A strong fault was said to run east and west from the New Invention to the south end of Bloxwich, but no exact account of it could be procured.

Tracing the Bentley faults towards the east, the great one diminishes its throw to about 210 feet beyond the Birch Hills, and the other splits into two, having a downthrow of 42 and 33 feet respectively. The New mine coal is here divided into two, called the Yard coal and Four-foot coal. The Fire-clay coal retains its name, but the Bottom coal is called either the "Four-yard coal," or the "Thick coal." They all rise towards the east at an angle of not more than 3°, but their outcrop is not exactly known. They must, however, all crop out before reaching Ryecroft, as none of them were found in Mr. Sparrow's shafts there. These shafts were said to be sunk in a very faulty and broken piece of ground, one fault especially being described as forming a complete semicircle. It is probable that the end of the Great Bentley fault here meets another fault coming from the north or north-north-east. That such a fault exists, having a downthrow to the east is almost certain, as we shall see presently.

From Birch Hills the lower coals are worked continuously up to Bloxwich, Goscott, and Pelsall, the coals being frequently injured or destroyed by the intrusion of white rock or green rock trap, but not broken by any large faults or dislocations. So far as could be ascertained, the beds have never been followed hereabouts to their eastern outcrop. Further to the north-north-east, however, at the Brown Hills, many old pits were formerly worked on the outcrop of the lower coals, and several collieries are now in operation at no great distance from it. We have already described the splitting up of the Bottom coal into two, called respectively the

* I have to acknowledge my obligations to Mr. George, of Bentley, for great assistance in examining this country. Almost all the details are derived from data he placed in my hands.

Shallow and the Deep coal. Now, in a small wood that lies half-way between "The Moat" at Pelsall, and "The Ford Brook," a pit has been recently sunk, in which the Deep coal was found to be only a few yards below the surface. Further north, on the east side of Birch Coppice, was an old pit where the Deep coal was only 60 feet dip, and it cropped fast beyond it, but then pitched overhead rapidly to east, as if approaching the boundary fault. At the Hammerwich colliery, just east of Norton reservoir, there was no Yard coal, the Bass coal being only 60 feet deep. All the beds both at Brown Hills and at Pelsall dip steadily to the west or west-north-west, at an angle of 5° or 6°, getting flatter as they deepen.

Two slight faults traverse them near the Brown Hills, the one having a downthrow to the south of 30 feet, the other a downthrow to the north of 60 feet. They both run about west-north-west and east-south-east (see map).

We get here then the bottom parts of the Coal-measures rising up close to the surface of the ground, as we did further south between the Birch Hills and Ryecroft, and may very well infer that this outcrop is continuous from one place to the other. If this outcrop continued to the east, we ought to get the Silurian rocks at the surface in that direction, all the way from Walsall to the Brown Hills. Over half the distance, from Walsall nearly to Shelfield, we do get the Silurian rocks rising to the east, and striking north-north-east till they are cut off by the Daw End and Linley fault, which brings in the Aldridge coals to the northward of it. These Coal-measures, which we have already seen reason to suspect represent the Thick coal series, were found in the Aldridge Trial pit to dip north or north-north-east at an angle of 30°. If this dip were continued for even a short distance, say ½ of a mile, it ought to bring in the upper Coal-measures.* A little beyond that we should get rocks that ought to lie above the Coal-measures. Now, about a mile north of the Aldridge Trial pit we get several large brick pits, opened in white, grey, and red marls, interstratified with pale wine coloured sandstones, that are certainly part, probably the the lowest part, of the Permian formation. These rocks dip slightly in various directions. They are continued certainly as far as the Lichfield road on the north-west; but beyond that the country is entirely covered by such a quantity of drift gravel, sand, and clay, that nothing can be seen between the Lichfield road and the Ford brook.

Further north, however, beyond Catshill, is another brick pit in these beds, a very short distance east of the outcrop of the Brown Hill coals. Here, then, at all events, between those two points, there must be a large fault or downthrow to the east, and it is probable that this fault runs south-south-west down to Ryecroft, decreasing in magnitude as it proceeds towards the south, so that after passing the line of the Daw End and

* An inclination of 30° continued through a flat country for 1,760 feet, gives us 880 feet for the thickness of the beds, measured at right angles to their dip.

Linley fault, its throw is very slight; and at Ryecroft, only sufficient to produce the troubled ground there met with.

I was informed at Pelsall, that in working the Shallow coal, (upper part of the Bottom coal,) from Pelsall Wood towards the west, it gradually got thinner and died out altogether in the direction of Fishley, the beds still dipping slightly to the west. In this central part of the northern district, namely, from Fishley, Wyrley Grove, and Norton, to the Walsall and Cannock road, there have been no coals worked, nor any explorations in search of coal so far as could be ascertained. To the west of the Cannock road, however, about Great Wyrley and Wyrley Bank, coal has been found in abundance, and there are many pits still in active operation.

The Wyrley Coal-measures, of which a description has been already given, p. 227, have always a dip to the west, or west-north-west, rarely at a greater angle than 5° or 6°. The most westerly shaft is that of the Waterloo colliery, near Longhouse, where they get a Five-foot coal at a depth of about 150 feet, which is not known in the pits further east. The inclination of the beds here is as much as 20° to the west-north-west, so that this coal rises to the surface before reaching the more eastern shafts. A coal had been found in the foundations of the houses, and in the wells of Wyrley Bank, which may be the same coal striking the top of the high ground there. There are only one or two small faults in this district, running about north-north-west and south-south-east, throwing down to the eastward 24, 36, or 48 feet (see map). The coals are said to be rather irregular, a coal being occasionally wanting in one shaft that is found in the others. For instance, in the Waterloo shafts the Cannel coal was wanting (see Vertical section, sheet 16, No. 3). The country here is often greatly obscured by drift, there being sometimes 60 feet of running sand, with large boulders. One of the boulders pointed out to me was granite, showing this drift to be part of the true northern drift. This quantity of drift renders it impossible to ascertain with accuracy the line of outcrop of any of the coals, they are therefore only dotted in the map, from the best evidence that could be got. The Wyrley Bottom coal was said to crop to the east of the Cannock road, between it and Jacob's Hall. At some old coal pits near the Old Mitre, nearly 3 miles south-south-west of Great Wyrley, I was informed by the late Philip Baker, of Landywood, that the Wyrley Bottom coal was worked at a depth of 70 or 80 yards (say 225 feet), dipping north-west at about 6°. Now, if this inclination were continued, and the surface were level, which it is as nearly as possible, the outcrop of this coal would be met with about a mile and a quarter to the south-eastward. Just south of Sneyd Pool, the outcrop of a coal was found in the canal, which was believed to be the Wyrley Bottom coal, and this spot is about a mile and a quarter from the Old Mitre. The dotted line marking the outcrop of the Wyrley Bottom coal therefore, has been continued from near Jacob's Hall to this spot (see map).

We have already seen that the outcrop of the Bentley Hey coal runs towards the New Invention, a little south-west of this, this bed, likewise, having on the whole a westerly or north-westerly dip.

Neglecting the faults, of the course and downthrow of which we have but little information, it is probable that this Bentley Hey coal passes just underneath the Wyrley Bottom coal. Now, the Wyrley Bottom coal is usually about 7 feet thick, and might, therefore, very easily be the same as the 9 foot Old Man's coal of Bentley. Moreover, this so called Wyrley Bottom coal has, at Wyrley, another 3 foot coal about 50 feet beneath it, which might very well be the same as the Bentley Hey coal (see antea, p. 281). We know that the Bentley Old Man's coal, and the Bentley Hey coal are the representatives of the bottom part of the Thick coal; if, therefore, the Wyrley Bottom coal, and the coal below it, are the same as the Bentley Old Man's and Bentley Hey coal, the coals at Wyrley must likewise represent the bottom part of the Thick coal.

But if this be the case, we ought to get, under these Wyrley coals, the true lower coals of the central district, namely, the New Mine, Fireclay, and Bottom coals. We have already seen that these latter crop out at the Brown Hills, about 3 miles east of Wyrley, having greatly altered both their names and characters, and become five coals instead of three. We have seen also that the dip, both at the Brown Hills and at Wyrley, was steadily to the west at a very slight angle, which, unless some interruption to it occurred between the two places, would carry the Brown Hills coals *underneath* the Wyrley, (see Horizontal section, sheet 23, No. 5,) and thus prove the latter to be in the place of the Thick coal of the central district.

Again, we have direct evidence that there are some coals beneath the Wyrley coals, which might represent the Brown Hills coals, though in a debased form and thickness; and we have evidence also that one of the Brown Hills and Pelsall coals becomes thin and worthless as it is followed to the west or in the direction of Wyrley. In the year 1826, Mr. Gilpin bored below the Wyrley Bottom coal, in a shaft about ¼ of a mile south-west of the turnpike gate at Great Wyrley. This boring was continued for a depth of 322 feet 7 inches below the Wyrley Bottom coal, and four or five thin bands of coal were met with at various depths below the Three foot coal, which is supposed to be the same as the Bentley Hey coal, (see Vertical section, sheet 16, Nos. 3 and 5).

I have already alluded to yet another evidence of the Wyrley coals being the representative of the Thick coals, and that is the total thickness of the Coal-measures at Wyrley. Including the boring mentioned above, we have 816 feet of Coal-measures there, without reaching the bottom of them, a thickness more than double that which is known in any other part of the field *below* the Thick coal; it is most probable, therefore, that this thickness includes the Thick coal, and some of the beds above it.*

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* I have entered more fully into this question, as being an important one for any one wishing to understand the structure of the northern district. The view taken in the text is the one first suggested to me by Mr. George, of Bentley, and the late Philip Baker, of Landywood. William

North of Wyrley and the Brown Hills we have none but the most scanty evidence of the position of the rocks till we come up to Beaudesert Park. In the former chapter several little scraps of sections have been given from about Hednesford. In the old workings north-west of Hednesford Pool many small step-like faults were said to have been met with, throwing the beds up and down in various directions, principally down to the west, a few yards at a time.

On the north side of the Castle Hill, in Beaudesert Park, a coal may be seen exposed in a small gulley; it lies in a horizontal position, and many old pits are scattered about the ground below, none of which were more than 30 yards in depth, and as they were all said to go down to the same coal, that must likewise have been horizontal, or nearly so. At the Brereton collieries, the general dip of the beds is south-east, at an angle of about 3° to 5°. There are 15 coals, some of which are very thin, in a total section of about 620 feet (see Vertical section, sheet 16, No. 1).

On the eastern side of the workings they drove out from the Fifteenth coal, which is there about 460 feet deep, towards the eastward, and came into a hard gravel rock. This was, doubtless, one of the conglomerates of the New red sandstone,* and the fault bringing it down to this position was part of the eastern boundary fault of the coalfield. This fault runs just under Mr. Poole's office. South and south-west of this point several shafts have been sunk through some of the beds of the New red sandstone down to the coals. These New red sandstone beds consist of red and white sandstone, and gravels, with some red marls; they appear to be quite horizontal. In the lower grounds they are about 70 or 80 feet thick, but measuring from the top of the inclined plane of the Hayes colliery, belonging to the Marquis of Anglesey, they are nearly 200 feet thick. The coals rise regularly from Brereton Hayes wood, where the Coal-measures are at the surface, at an angle of 3°, so that under the New red sandstone,

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Arblaster, of the Brown Hills, coincided in its correctness. The general opinion in the district is, I believe, against it. It is supposed that some great north and south fault runs between Wyrley and the Brown Hills, and that all the coals north of Bentley are the lower coals of the central district. I have, however, never heard of any evidence in support of those views.

* Mr. Vernon Poole, Lord Talbot's agent, gave me this and all other information as to the mines under his charge.

they crop up into the base of that formation. In the pit below the foot of that inclined plane, for instance, they had—

	FT.	IN.	
1. Gravel	80	0	New red sandstone.
2. Red and yellow marl	6	0	
3. Rock	5	0	
4. Clod and batt	5	6	
5. First coal	4	6	
6. Intermediate, with Three coals	125	0	
7. Fifth coal	4	0	
	230	0	

While at the top of the incline they got—

	FT.	IN.	
1. Gravel	120	0	New red sandstone, 189 feet.
2. White sand rock	69	0	
3. Clod	110	6	
4. Fifth coal	4	0	
	303	6	

A little beyond the top of the incline is a fault running north-east and south-west, throwing down to the north-west 25 yards.

About ¼ of a mile north-west of this another pit has been sunk, in which they got—

	FT.	IN.	
Gravel	186	0	New red sandstone, 315 feet.
Ditto and White sand rock	129	0	

when they came down into the Coal-measures, and were stopped by water; they then bored into a coal just below which was supposed to be the Fifth coal.* Farther on, nearly a mile to the north-north-west, in a field of the Birches farm belonging to Lord Lichfield, just south of the Rolling Mill Pool, a boring was made some years ago, the account of which was given me by Mr. George. In this boring they passed down through 418 feet of alternations of "red rock," "gravel," "marl partings," &c. Below that they came into "black marl," and then had alternations of "black marl," "red marl," "white rock," "ironstone," and "red rock," and marls to the total depth from the surface of 612 feet. At a depth of 545 feet, they found a coal 13 inches thick, with a foot of fireclay below it, and alternations of "red rock," "red marl," and "blue binds" below that. What these lower rocks were, whether they were true Coal-measures, or whether they were Permian rocks, which, as we have seen, do contain

* I was indebted to the late Mr. Figgins for information as to all the collieries under his care.

fireclay and coals, it is exceedingly difficult to say. The mention of ironstone would seem to give it in favour of their being Coal-measures, but there are ferruginous concretions in some of the Permian rocks which in the auger of the boring rods might seem to have been derived from true Coal-measure ironstones.*

From the Brereton district, where, as we see, the Coal-measures are partly covered by some beds of the New red sandstone formation, resting unconformably on the edges of the coals, a range of hills runs south-west, ending in the bold ridge of the Hednesford Hills. All the high ground of this range is certainly composed of beds of soft red and white sandstone, and gravel, belonging to the New red sandstone formation. Along their south-east margin, old coalpits are abundant, and wherever a little valley cuts into them, the old coalpits run down for a short distance. Old coalpits, with abundance of coal shale on their banks, are found on both sides of the Hednesford Hills, and everything goes to make it probable that at this northern side of the coal-field the boundary is formed by an unconformable overlap of the New red sandstone resting horizontally, or nearly so, on the slightly inclined edges of the Coal-measures. That it conceals also, in some places, Permian beds as well as Coal-measures, is rendered probable from the fact that Permian marls and sandstones peep out from underneath it at Lutterworth, on the south side of the Hednesford Hills, where they are worked in a deep excavation as a brickpit.†

The reader will recollect that the southern margin of the coal-field was formed by the Permian rocks resting on the upper Coal-measures in *apparent* conformity, both being horizontal, or dipping at the same imperceptible angle to the south. Both the north and south boundaries of the coal-field, then, are formed by the simple denudation and removal of the superior rocks, and the consequent appearance of the lower ones at the surface of

* Boring is at all times an operation so liable to mistakes, and so likely to give deceptive indications, that I am never inclined to put too much faith in the details of its results.

† Wherever bricks are made on the margin of the coal-field from these Permian marls, they are of a peculiar and excellent quality, forming the "blue bricks" so well known in the neighbourhood. They are of a deep purple colour, very hard and smooth, with a partially glazed surface.

the ground; the only difference in the two cases being that in the one the superior rocks were in apparent conformity to the inferior, while in the other they were distinctly and apparently unconformable.

We will now examine the east and west boundaries of the coal-field. One difference between these and the north and south boundaries will strike us at the first glance of the map. Instead of being irregularly and deeply indented, and conforming to the natural surface of the ground, advancing or receding with its hills and valleys, the east and west boundaries are regular, and equable, preserving a certain mean course with great persistency, and when curving, doing so gradually, and with a wide and steady sweep, forming a curve of large radius. The north and south boundaries are like an indented coast line, the east and west are like artificial roads, going nearly straight across the country, with but little respect to the variations in its surface. These boundaries, indeed, are not the result of mere denudation alone, (or of that action by which the present configuration of the surface has been produced,) but of denudation combined with great longitudinal faults, which at the very period of their formation produced a sudden change in the ground along their line, so that no subsequent lowering of the level of the ground, though it may slightly shift the position, can much alter the character of that change. This difference in the nature of the two boundaries has a very important practical bearing. When the boundary of a coal-field has been formed by simple denudation, without any faults in the neighbourhood, we can follow the beds of coal under the other rock without much regarding it; it is simply an additional matter of so much thickness interposed between the surface and the bed, and if the dip of the two rocks be known, and the surface be levelled, the depth of the coal can be calculated with the greatest facility. When, however, the boundary of a coal-field is caused by a fault, the mere dip of the rocks is no longer a trustworthy guide to us. The "throw" of the fault, as also the angle of its inclination, or "hade," is *à priori* unknown to us; we have therefore commonly no means of judging how far the coal bed is depressed on the other side of the fault below its level on this, and if we

knew that, we should perhaps have no means of ascertaining how far the fault "haded," "overhung," or "inclined;" or, in other words, how far we ought to go beyond the broken end of coal on this side of the fault before we felt sure that we were standing over the other end of the bed on the other side of the fault.

The determination of the nature and character of the boundary faults of the coal-fields, therefore, is one of the most important practical points which it is the province and the duty of a Geological survey to solve, since it is one of those least within the power of an individual observer, examining only small and isolated localities, to understand and explain.

I was at one time strongly inclined to entertain the supposition that the boundary faults of the Midland coal-fields were of the nature of cliffs rather than of fractures.

It appeared from certain circumstances rather probable that the previously existing Coal-measures had been almost entirely destroyed and washed away, except in the parts where they are now seen at the surface; that in those parts they had been left as islands, round which the beds of the New red sandstone had been deposited, abutting against the old coal-cliffs, its beds taking the place of those that had been swept away. Facts such as those we have seen in the Brereton district, where the coal cropped up into the New red sandstone, without the intervention of any fault, lent strength to this hypothesis. Soon after the commencement of the survey of the South Staffordshire coal-field, however, my belief in this hypothesis was greatly shaken, and it was finally abandoned, so far as the supposition of any long line of lofty cliff was concerned, having a more or less nearly perpendicular face, with several hundred feet of New red sandstone deposited against it. The very form of the east and west boundary faults of this coal-field was against this supposition. Direct evidence against it, as to the Westbromwich district at all events, was soon obtained, and all doubt was finally set at rest when the boundary between the New red sandstone and Permian formations was surveyed. For it then appeared that sometimes a broad tract of Permian rock lay next outside the

boundary fault, sometimes none at all. If, therefore, the gap caused by the supposed denudation of the Coal-measures had been first of all filled up by Permian, it would follow that that formation itself had subsequently suffered an almost equal amount of destruction, and another great cliff formed; and that in some places the whole of the Permian formation had been utterly removed, and the old Coal-measure cliff re-exposed, only to be again concealed and the second gap filled up by subsequently-formed beds of New red sandstone. Such a recurrence of so singular a phœnomenon was too much for the wildest hypothesis to affirm; and we shall, I think, see reason to conclude that the east and west boundaries of the coal-field are not only genuine faults, clean-cut fractures, but that they were produced late in the New red sandstone period, if not subsequently to it altogether.

The practical bearing of this discussion will be at once seen, if we reflect that on the first supposition of the boundaries being cliffs, a very large part of the Coal-measures, with their accompanying wealth of coal and iron, must have been removed from the spaces between our present coal-fields; if, on the other hand, the boundaries are faults, we have still all or the greater part of the Coal-measures concealed and untouched under the New red sandstone of the great central plain of England.

We will now examine a little in detail these two boundary faults, commencing with the eastern one near its southern extremity on the Birmingham and Halesowen road.

At Perry Hill the angular trappean breccia of the Permian rocks is seen in the cutting of the road, the Red rock extending up to the turnpike. Near the Hagge, Round Hill, and "Barn," yellow Coal-measure sandstone may be seen. Just where "ra" of "Brand Hall" is in the map is an old quarry in the calcareous conglomerate, described before as occurring in the Permian rocks. This band of calcareous conglomerate can be traced thence to Barnford Hill, where it is much further from the fault than it was at Brand Hall. This looks as if the fault increased in amount as it ran south, concealing more and more of the Permian rocks, and thus bringing this conglomerate bed nearer and nearer to it.

About 350 yards south-west of Langley mill there is an old pit only 130 yards (390 feet) deep, which, from the quantity of Silurian shale full of fossils on the bank, must have had almost its lower half altogether in that

formation.* This is very near the boundary fault, but how the Silurian shale comes to be so near to the surface as even 100 yards is not easy to explain. From some old mining plans of this locality lent to me by Mr. S. H. Blackwell there appeared to have been here a curious complication of faults, the clue to which I did not succeed in unravelling. A little north of this, in Mr. Chance's pits, the Thick coal thinned out to 7 feet as it approached the fault. Red rock can be seen at the surface very near the line of the fault as it is drawn on the map. It is probable, then, that there is here a complication similar to that described before in Lord Dartmouth's Heath pits at Westbromwich.†

North of Oldbury the fault is very well traced. At the Flash we have the Thick coal 60 yards (180 feet) deep on one side, and 212 (636 feet) on the other, giving a downthrow of 152 yards (456 feet); but the amount of "red rock" sunk through was not known. At Mr. Bennett's pits at Ireland Green the Thick coal is 170 yards (510 feet) deep, while on the other side of the fault, near "the Oaks," it is 288 (864 feet), giving a downthrow of 118 yards (354 feet). At the Terrace pits at Christchurch the Thick coal is 252 yards (756 feet) deep, and it was said to be only 45 yards (135 feet) to the bottom of the "red rock," the downthrow of the fault being 88 yards (264 feet). This fault continues to hold its course to the northward for a mile beyond this point, having still a downthrow to the east of 60 or 80 yards (180 to 240 feet), till it appears to be cut off by the Tipton and Hilltop fault. North of the Cross Guns inn, however, in the Wolverhampton and Birmingham road, it is no longer the boundary of the coal-field even at the surface, as there is no Red rock on either side of it. At a new pit sunk about the foot of the "L" of "Lyndon" in the Ordnance map, they have now sunk below the Broach coal without meeting with any red rock. From the depth of the Broach here it will be about 200 yards (600 feet) to the Thick coal. About one third of a mile to the south of this spot is the Lewisham pit, at which the Thick coal is 290 yards (870 feet) deep, and there is said to be 105 yards (315 feet) of red rock above the Coal-measures. It is doubtful whether there be a fault, downcast to the south, between these two points, or whether the lower level of the Thick coal at the Lewisham pits is due merely to the southerly dip from those at Lyndon. A dip of only 10° would be sufficient

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* It is a curious instance of the frequent want of the commonest knowledge in this district, that an intelligent man who acted often as a "ground bailiff" in the neighbourhood, his father and brother being both of that profession, was yet not aware that it was impossible to find coal beneath shale containing Silurian fossils.

† A dotted line was drawn on the map to call attention to the probable connexion between these two places. This connexion subsequent workings near Spon Lane have proved not to exist on the Thick coal level all the way, at all events not to run along the exact line drawn in the map, though it may run a little farther east of it.

for the purpose. If there be no fault, the Permian red rock must come in either by simple capping of the Coal-measures, or it may have been originally deposited in a sudden hollow of erosion existing formerly in the Coal-measures of that locality. East of Lyndon and north of the "red rock" the Thick coal is said to end at a depth of 200 yards (600 feet) against a mass of "rock and rig." This is probably an extension of the "Rock fault" found both in the "Heath" and "Lewisham" pits as before described (p. 255.)

From this point we have to traverse a district of very great obscurity for two or three miles. A ridge of drift gravel runs from Sandwell park by Westbromwich old church to Charleymount. This drift is in some places 120 feet thick, and effectually screens all the rocks below from observation. At a small public-house between Bird End and the Wigmoor station gas escapes from the ground in such quantity that it is used to light the house and the neighbouring cottages. It is almost certain, then, that there are Coal-measures under this spot, though they can only contain the lowest beds of coal. In the cutting of the railway to the north-east of Crank Hall farm Silurian shale full of fossils was found lying horizontally.

In the road going from Wigmoor station to Newtown, red rock may be observed apparently horizontal. "Red rock" spreads from this point over all the country to the north and east. Trusting to these facts, a dotted or supposed fault has been drawn from the Cross Guns to Sunday Bridge. From this point towards the north we have on one side of a certain line running about north-by-east, Silurian shale dipping very slightly to the south; and on the other side, red rock, which, whenever it is exposed, is found to have an easterly dip.

On the Walsall and Birmingham road, as we rise from the Silurian flat about the Bell, on to the gentle elevation on which the Goughs Arms stands, we meet first with some pale wine coloured mottled calcareous sandstone, above which, in a brick pit, we find some grey and mottled clays and marls, with interstratified sandstone bands, that dip apparently east-south-east at 40°. Over these, in a field opposite the Goughs Arms, is a band of the calcareous conglomerate, just the same as that of Barnford Hill before described, dipping east-south-east at 20°. These are all evidently Permian beds. On the higher ground, where "Quarry" and "Snail's Green" is written in the Ordnance map, we find a large gravel pit opened in the quartzose conglomerates forming the base of the New red sandstone.

Further north we get Red sandstone and marl, probably Permian, on a level with the Barr limestone near "the Skip."

It will be more convenient now if we go to the northern end of the eastern boundary fault and trace it southwards. In the Brereton colliery they drove through the fault, and found some part of the conglomerates of the New red against the fifteenth coal at a depth of 460 feet. New red conglomerates rest above the Coal-measures here on the upcast side of the fault, but it is quite possible that those found at this depth in the workings are much higher in the series than those found at the surface at

Stile Cop and the neighbourhood. The downthrow of the fault, therefore, may be a great deal more than that 460 feet, and there may be a succession of step-like downthrows outside it again. One such step-like downthrow was observed in a gravel pit at no great distance from the spot. Starting from this point along the line drawn on the map to the southward, we have abundant evidence of "Red rock" on one side, and of Coal-measures on the other, lying just below the surface of the ground in a nearly horizontal position. The Red rock is the ordinary Red sandstone of the New red formation. In Beaudesert park it is apparently part of our lower subdivision of that formation, namely, the Brick red sandstone; about Cannock wood the beds appear to be the white and brown sandstones of our intermediate division, and on Old Lodge Hill are some excavations in red marl that appear to be just the bottom beds of the upper sub-division, the Red marls. From this point scarcely anything can be seen or known for about two miles, till we arrive at the Hammerwich colliery just east of the dam of the reservoir. In these coalpits they have driven to the east, and struck the Red rock fault just under where the feeder falls into the new branch of the canal. The Red rock is seen in the canal to be the lower subdivision of the New red sandstone, and the coals are known to be in the lowest portion of the Coal-measures. So far we have seen no Permian rocks, though it is highly probable that rocks of that formation lie concealed under the New red sandstone, and between it and the Coal-measures on the downcast side of the great fault. This probability is increased by the appearance of a very considerable mass of Permian rocks intervening at the surface of the ground between the Coal-measures and the New red a little further south. It is probable that the boundary fault splits here into two; that the downthrow of the western branch is sufficient only to bring the Permian beds to the level of the Coal-measures, while the eastern branch brings the New red down side by side with the Permian. Instead of one great downcast we have two step-like ones. We have already seen reason to suspect that the western branch of the fault gradually diminishes and dies out towards Ryecroft. The eastern branch continues as the boundary fault, and further south the Coal-measures rise to the surface either by inclination of the rocks or by dislocations, so that we again get their beds on a level with the New red sandstone, and the amount of the downthrow effected by the fault becomes as great as ever. Where the Daw End and Linley fault strikes into the boundary fault another split seems to take place in the latter, again bringing out the Permian rocks; but as the Silurian beds, and even the bottom beds of the upper Silurian formation, are here on a level with the Permians, the downthrow here must of course be as large, if not larger, in amount than in any other locality. As we go southwards more and more of the Permian rocks seem to be exposed to the east of the fault, or its downthrow seems to be decreasing; and there is some reason to suppose that another split takes place about Sunday Bridge into two or more faults, the total effect of the downthrow being distributed over a much wider surface, reckoning from the boundary of the Red rock, over the district between West-

bromwich and the country west of Harborne, than in any other part of the boundary of the coal-field.

The western boundary fault of the coal-field commences at the northern slope of Wychbury Hill. Thence to Oldswinford we have the Brick red sandstone and conglomerates on one side, and the upper Coal-measures on the other side of the fault. North of Oldswinford we get the beds below the Thick coal on the upcast side of the fault, sometimes cropping out at a very great angle, and on the downcast side we get a narrow band of Permian, soon overlaid by the base of the New red sandstone. Near Wordesley the New red sandstone dips at an angle of 20° to the west; the Permian, therefore, must here dip, at least, at as great an angle from the fault. At Bug Pool they have sunk through the fault down into the Thick coal below in consequence of its great overhanging ("hade," "overlie," "underlie," "inclination"). In these pits they had 40 yards of "red rock," and got the Thick coal at 126 yards from the surface. Between Wordesley and Salters Hall, Mr. Bond sank 280 yards (840 feet) in the Permian rock at about 200 yards from its surface boundary, without passing through it into the Coal-measures. Near the Stand Hills some recent sinkings of Messrs. Davis have, I believe, passed through it near the boundary at a depth of not more than 20 or 30 yards, 60 to 90 feet.

The junctions of the great faults called the Brockmoor, Corbyns Hall, and Shut End faults appear to have little or no effect on the character of the boundary fault. At Kingswinford the Brick red sandstone of the New red formation comes up against the fault, and we have that sandstone on the one side and the Coal-measures with the Thick coal 140 yards (420 feet) deep on the other. Before reaching Himley Park the boundary fault seems to split and let in between its branches a wide tract of Permian rocks, occupying the eastern half of Himley Park, all Baggeridge Woods, and great part of Penn Common.

Indications of the extension of the west branch of this fault into the New red sandstone were observed as far as the Lloyd Farm, by Mr. Beckett of Wolverhampton.

The eastern part or true boundary fault runs as drawn in the map, with a curved line up to Sedgley Hall farm; quarries or cuttings in the Permian rocks being observed at intervals all the way on one side, and coal measures on the other. At the turnpike gate west of Sedgley some small pits in a patch of Thick coal were worked formerly, and in the year 1828 a trial pit was sunk just east of Sedgley Hall farm. In this trial pit the Thick coal was found at a depth of 323 feet, dipping to the west at an angle represented as only 12°. But as a quarry in the Permian rocks may be seen just north of the farm, and the limestone ridge rises immediately on the east of it, it is clear that there must be a fault on each side of this patch of Coal-measures. Moreover the first 120 feet in this shaft was described as "red croprash rock and marl," which were in all probability Permian rocks. From these facts it is probable that the boundary fault "hades" here, at a comparatively low angle, to the west, leaving a long space of "barren ground" between the ends of the Thick coal on opposite sides of

the fault (see Horizontal sections, sheet 24, No. 6). This is probably the general character of the boundary fault in the southern part of its course. Along the flank of the Sedgley ridge all we know of the boundary fault is that there are Silurian rocks on the high ground on one side, and Permians in the valley below.

In the Parkfield coalworks beyond, as also in the Cockshutts and Green Lanes collieries, the Coal-measures are very violently broken and contorted*, and a very common feature is a rapid dip of the coal measures towards the fault as they approach it.

Patches of Thick coal were found in the shafts south of the Fighting Cocks dipping at the fault. Mr. R. Smith informed me, that at one spot, after the Blue flats ironstone had risen to the surface in the form of an S from a depth of 100 yards, so that one shaft passed through the same measure three times, they sank a shaft a little further west, in which, after passing through a few yards of "Red rock," they came down to some Thick coal, dipping west at a gentle angle, which they followed for a few yards till they found it cut off by another fault, hading rapidly to the west.

At a pit lately sunk in the Green Lanes they found the Brooch coal at a depth of 30 or 40 yards (90 to 120 feet), dipping west at 2 in 3 (= 34°), but as they sank deeper they found the dip of the beds increasing to 2 in 1† (= 63°). This was very close to the line of the fault. At the tunnel of the railway at Wednesbury Heath the New mine coal cropped very gently up towards the fault for several hundred yards, and was exposed in the cutting of the railway. Just at the east mouth of the tunnel they met with the "Red rock," dipping westerly, and the coal as it approached it was likewise seen suddenly to dip towards the west, being much broken. The Blue flats ironstone, 160 or 170 feet below the New mine coal, was worked under the tunnel for nearly 100 yards beyond the end of the New mine coal, which would make the "hade" of the fault not much more than 30° from the horizon. At other places, however, between here and Wolverhampton, the fault seems from the workings to approach very nearly to a vertical. From Wolverhampton to within a mile and a half of Cannock, Permian rocks are invariably those found below the surface on the downcast side of the fault; but at Wyrley Bank these rocks seem to be dying out, and beyond that the Brick red sandstone and conglomerate of the New red is alone seen. A split of the fault is thought to take place near the Walk Mill, one branch proceed-

* Not far from the Fighting Cocks a pit was sunk formerly where Mr. Pugh's house now stands, in which pit the New mine coal, 6 feet thick, took 30 yards (90 feet) of perpendicular depth to traverse the width of the shaft, 7 feet. It dipped therefore at an angle of 81°.

† That is, in a 7 foot shaft, after passing through one measure on the crop side of the pit, they sank 14 feet deep before they left it on the dip side of the shaft.

ing due north towards Stafford into the middle of the New red, while the other continues to form the boundary of the coal-field as far as Hednesford Pool, when that likewise so far dies out as to allow some of the beds of the New red sandstone to appear on the upcast side of it. The country is here so obscure that it is very difficult to say how this takes place,—whether the fault becomes evanescent, or whether the beds of New red sandstone on opposite sides of it stood originally at very different levels in the formation.

We will now briefly recapitulate what we know of the Permian rocks surrounding the coal-field, and then describe the position of the beds of the New red sandstone around it.

The little patch of Permian marl, with bands of sandstone and large ferruginous and calcareous nodular concretions which shows itself at Lutterworth, appears to be, as nearly as possible, horizontal, passing under the New red sandstone* of the Hednesford Hills to the north, and not extending far over the coal measures on the south. Nothing more is known of it.

There is a patch of red marl of a very similar character at Rumour Hill, east of Cannock, which may be Permian; or, as there are red marls in the coal-measures of this coal-field, it may belong to them. As it was entirely surrounded by coal-measures and much obscured by the drift, the latter supposition was thought to be the safer to adopt.

The Permian beds of Walsall Wood and the neighbourhood have already been sufficiently described, as have those extending from Barr to near Harborne on the east side of the coal-field.

There are still, however, a few words to be said on the long strip of Permian beds extending from Wyrley Bank to Himley Park. Brick pits are extensively worked in the marls of this formation at Wyrley Bank and Essington Wood, the beds dipping west and north-west at 10° or 15°. At Essington Wood is an old quarry, in a dark trap, a kind of greenstone or basalt, some of the fragments assuming one form and some the other.

* I was for a long time in doubt whether the very incoherent sandstones and gravel-beds of the Hednesford Hills were really undisturbed New red sandstone, or the drifted washings of that formation deposited here at a much later period. Professor Ramsay, however, on examining it, said it was so like some of the undisturbed New red of the north of Staffordshire, that we decided to consider it part of that formation.

This appears to be a trap-boss surrounded by Permian marls, but what are the relations between the two it was impossible to discover. Brown sandstones are seen in some of the lanes a little west of these brick pits, which were said by Mr. Hull to resemble the Permian sandstones of North Staffordshire. The boundary, however, between the New red and Permian formations is here exceedingly obscure, and continues so as far south as Wolverhampton. The dotted line on the map, therefore, must be taken as a mere provisional and uncertain boundary.

Pale wine-coloured and nearly white sandstones, often highly calcareous, were exposed in the new cuttings of the railways at Wolverhampton, dipping sometimes at an angle of 5° or 6° to the west. These were believed to be Permian sandstones. Just west of the road, however, near the windmill in Stafford-street, good brick red sandstone, certainly part of the New red, is well shown in a quarry, and appears to be quite horizontal. The new shaft for the waterworks* at Goldthorn Hill is sunk entirely in mottled calcareous sandstones and marls of the Permian series. These were said to dip westerly across the shaft at an angle sometimes of 30°. On the crest of the hill to the westward are some gravel pits opened in the pebble beds of the New red sandstone, which likewise appear to have a slight westerly dip.

Indications of Permian beds on one side of the boundary and a gravel ridge (pebble beds of the New red) on the other are found from Goldthorn Hill to Penn Common. Permian marls

* A practical geologist would certainly never have thought of recommending this site for a deep well to supply waterworks. The boundary fault of the coal field is scarcely half a mile on the east of them, being in all probability a water-tight barrier, while as the dip of the rocks must of necessity be a general one to the west, the great mass of water will follow that inclination of the beds, and lie under the country between Tettenhall and Trysull. Had the existing wells at Tettenhall been carried sufficiently deep they would have come down into the very beds that crop out at Goldthorn Hill; this, however, the waterworks company were said to be unable to do, in consequence of a clause in their Act of Parliament prohibiting them from going deeper; this clause having been introduced by the influence of the Staffordshire and Worcestershire Canal Company, from a groundless fear that so deep a sinking would cut off some of their water.

and sandstones may be seen in the lower part of the brook south-east of the Lloyd House, and typical New red sandstone at the mill by the Wood-houses. Near Gospel End, the Permian beds consisting of alternations of reddish and pale brown sandstones with red marls; and a band of slightly calcareous conglomerate may be seen in some road cuttings. These Permian beds have everywhere hereabouts a dip of 5° or 10° to the west-north-west. A large mass of calcareous conglomerate, similar to that of Barnford Hill on the east of the coal-field, was found and mapped by Mr. Hull in Baggeridge Wood. At Hawkeswell Rough, north of Himley Park, good New red sandstone is seen apparently horizontal, while on higher ground to the eastward are two quarries of pale Permian sandstone, one of which dips north-east and the other south-east at 10°. A fault, therefore, must here separate the two formations. This is believed to extend northwards into the New red sandstone and southwards across Himley Park to the boundary fault. Just behind Himley Hall the conglomerates of the New red sandstone are well shown in a large cliff dipping north at 10°. Pale slightly calcareous sandstones may be seen about the Streights dipping north-west at 5°.

A narrow belt of Permian rocks just peeps out between the New red sandstone and the boundary fault between Kingswinford and Oldswinford. They consist principally of pale red calcareous sandstone and red marls. At Audenham Bank a concretionary mass of compact pale grey limestone, with a smooth conchoidal fracture, was exposed in the bank of the road lying in some red marl. It did not seem to extend far, however. Professor Ramsay informs me, that in a new road cutting near Dennis, Permian sandstones and marls containing slight traces of the trappæan breccia may now be seen dipping west at 10° or 15°.

The Permian district round the south end of the coal-field is the largest and most important one of the neighbourhood, and worthy of a little more detailed description. When the country was first surveyed, no doubt was entertained that the Clent Hills consisted of trap rock, and that the angular fragments seen at the surface and in the small quarries were the local débris of the

solid rock below. Professor Ramsay, who spent a day with me there in 1849, concurred in these views, which are those published by Sir R. Murchison in his "Silurian System." On examining the Lickey Hills, however, it was soon perceived that the angular trap débris there rested on red sandstones, which had not then been separated from the New red sandstone formation. This trappean débris, therefore, was taken for local drift, derived from the Clent Hills. In some places, however, it was seen apparently to pass under beds of the New red sandstone age, and it was therefore supposed there might have been a drift of it during the formation of that rock, and another of more recent epoch, deriving its materials either from the breccias of the New red, or directly from the Clent Hills, or partly from one and partly from the other. While examining some of these angular trap breccias, I was often led to entertain doubts as to their being really any trap *in situ* in the Clent Hills, but the trappean prestige was so strongly upon them that I did not venture to disturb it. The district indeed, though frequently traversed, was never *surveyed*, as the "red rock" country was left till after the coal-measures and older rocks were completed. Before even the coal-field was finished, I was called away to Ireland to assume the local direction of the survey there in consequence of my predecessor Professor Oldham's departure for India; and it was not till this year (1852) that I was enabled to return for a short time to complete my work sufficiently to allow of its publication. In the meantime Professor Ramsay and Mr. Hull had examined and made themselves masters of the Permian rocks, as shown in the north of Staffordshire; and Mr. Hull examined and partially surveyed the Permians round the South Staffordshire coal-field. Mr. Hull satisfied himself that the angular trappean breccia belonged to the Permian formation, and was a characteristic portion of it. In the spring of 1852 Professor Ramsay joined me in the district, when I had completed the examination of the coal-field; and we were soon aware that a more detailed and accurate survey of the Permian rocks round the south end of the coal-field was necessary. As I was compelled to go to London in order to make arrangements for the publication of this memoir and free myself for what had become my more legitimate duties in Ire-

land, Professor Ramsay very kindly consented to devote some of his own time to the examination of this district; and the following are the results of this examination as he has provided me with them.*

The Clent Hills and Wychbury Hill (formerly considered to be trap, and coloured as such in my own working maps,) consist altogether, as far as their higher portions are concerned, of the angular trappean breccia, with no appearance of any trap *in situ* at all, "the fragments being principally composed of greenstone, with a little sandstone and a porcellanic looking slaty rock like some of those west of the Stiperstones." The beds are rudely stratified, and appear to dip south or south-south-west at an angle of about 5°. This angular trappean breccia may be traced continuously from Hagley Park to Bromsgrove Lickey, forming the uppermost of the Permian beds, having always a southerly dip, and passing in that direction under the "pebble beds" or conglomerates of the New red sandstone.† The breccia is frequently a very deep red, the fragments being cemented together as it were by a red marly substance. When well exposed it is seen to pass insensibly at its base into red marls, the fragments getting smaller and finally disappearing.

Underneath this are red sandstones and marls, and then a band of highly calcareous sandstone comes in, showing itself under Square coppice at the Lickey, at the limeworks of Newtown, near Hunnington, near St. Kenelmn's chapel, and west of the parsonage in Hagley Park. Near the latter spot the pebble beds of the New red appear to overlap the trappean breccia and approach the calcareous band,‡ running up nearly to the obelisk. They are then cut off by a fault which has been recently exposed in a new gravel pit, and the trappean breccia

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* I have entered on this personal detail in order that I may not seem to be taking more credit than I deserve, and also to strengthen my statements by the authority of Professor Ramsay.

† This angular trappean breccia re-appears againat Enville, and also in Shropshire, and seems to be characteristic of the Permian beds through a great extent of country.

‡ Unless this be the effect of a fault, a part perhaps of the boundary fault of the coal-field.

again comes out to form Wychbury Hill. A similar fault, bringing down the gravel beds to abut against the trappean breccia, is believed to terminate it at the Lickey Hill (see Map). The lower beds of the formation, consisting of red and brown sandstones and marls, with one or two calcareous bands, spread over the country from Hagley Wood to Frankley, Kitwell, and the Lappal tunnel, the beds having, doubtless, a general slight inclination to the southward, with several minor flexures. Another patch of the trappean breccia caps the hill on which the well-known trees called Frankley Beeches stand.

From Frankley the dip appears to be south-south-east, and this inclination brings in the trappean breccia again in that direction, dipping in the lane north of Merrit brook at 20° to the south-south-east. Here all the Permian rocks are cut off to the eastward by a fault, believed to be an extension of the eastern boundary fault; and New red sandstone occupies the triangular district between Shenley Court and Weoley Castle. Brick red sandstone comes in south-east of the last-named trappean breccia, resting on it at one place apparently in a horizontal position, but in another appearing to dip from it at an angle of 15°. This sandstone, together with the Permian and other rocks between it and the Lickey, are all believed to be cut off by a fault running north-east and south-west, which will be described presently.

We have now very briefly to examine the position of the rocks forming the New red sandstone formation. The northern part of Cannock Chase consists of red sandstones and pebble beds belonging to the middle and lower portions of the New red. These rocks must dip very gently to the north-north-east, in which direction they pass under the upper red marls on the north side of the rivers Sow and Trent. Similar beds on the east side of the coal-field between Lichfield and Rugeley, having a similar dip, likewise pass under the red marls north of the river Trent. These marls, partly by the northerly dip of their beds, partly by the rise of the ground in that direction, become eventually capped by two large patches of Lias, the one occupying Bagot's Park and part of Needwood Forest, the other spreading round Christchurch on Needwood (see Map, sheet 72, south-

east). The sandstones under these marls rise to the westward also, and crop on the high ground between Ingestrie and Stafford; but the bottom parts of the red marls are suddenly brought in again by a downcast fault, which is believed to be an extension of the branch that comes from the western boundary fault near Cannock. In consequence of this depression of the beds the red marls spread themselves over all the country from Stafford to Penkridge and Brewood as far south as the southern extremity of Chillington Park. From this point the middle and lower parts of the New red sandstone are seen to stretch uninterruptedly to the southward, till they are again covered by the red marls of Worcestershire a little south of Bell Broughton. Between Cannock and Wombourne the general dip of these beds must be to the north-west, both from their passing under the red marls in that direction and from their allowing the Permians to rise from beneath them on the south-east.

From Wombourne to the neighbourhood of Stourbridge they probably scarcely deviate from horizontality, except where they rise to the eastward to allow the Permian beds to appear at the surface, or are tilted slightly on approaching the boundary fault of the coal-field. South of Hagley and Clent the general inclination of the New red must be to the southward, the pebble beds rising on to the flanks of the Clent Hills,* and the red marls setting in south of Bellbroughton and at Chaddesley Corbett, and Elmsley Lovett.† Between these places the red marls are underlaid by a white sandstone exactly similar to that under the marls near Albrighton and about Codsall, Brewood, Penkridge, and Rugeley. Plants were recently found in it by Professor Ramsay near Bellbroughton similar to those

* The quartzose gravel or pebble beds of the New red sandstone about Clent and Calcot Hill rest directly on or against the angular trappean breccia of the Permian formation. Notwithstanding the incoherent and easily transported character of the materials of the two formations, their boundary is wonderfully distinct, so much so that it can be traced across ploughed fields merely by the nature of the pebbles and fragments lying on the surface, so little have they been mingled either during the deposition of the New red or at any subsequent period.

† From this to the end of the chapter is an account of the work done by Professor Ramsay, assisted by Mr. Howell.

described by Sir R. Murchison and Mr. Strickland in their paper in the 5th vol. of the Geological Transactions.

These Worcestershire marls have a general south-easterly dip, which brings in the Lias east of Hanbury. My colleague Mr. Howell, partly by himself and partly in conjunction with Professor Ramsay, had mapped the red marls continuously from the Lias of Needwood Forest, by Lichfield, Tamworth, and Birmingham, to Droitwich; and Professor Ramsay informs me that this Lias near Hanbury is precisely similar in mineral character to that of the outliers of Needwood in Staffordshire, consisting of "pale clay below, with interstratified beds of pale blueish argillaceous limestone, covered by brownish white, very thin bedded, micaceous sandstone, containing casts of small bivalve shells." The extension of this Lias to the eastward is cut off by an upcast fault running north-west, in which direction the red marls are themselves cut off to the east, and red sandstone brought up against them, probably by the same fault running generally north in a slightly curved line. It is not improbable that this fault runs much farther north, and is in some way connected with the western boundary fault of the coal-field. If so, we have strong presumptive evidence for a fault, running generally north and south with a downthrow to the west, for upwards of 40 miles, or from the latitude of Stone to that of Droitwich (see map, sheets 72, south-west; 62, north-west and south-west; and 54, north-west).

The New red sandstone between Bromsgrove and the Lickey Hill, has a general dip to the south-west and south, and the white sandstone comes in around Bromsgrove, passing under the marls to the southward of it. This white sandstone likewise contains fossil plants at Hill Top near Bromsgrove. It appears to pass laterally as well as downwards, into red sandstone. If we start from the natural boundary of the red marl, south of Bromsgrove, and walk across the country to the pebble beds of the Lickey Hill, a distance of about four miles, we should find that every exposed piece of rock showed a dip to the southward or south-westward, sometimes at an angle even of 10°. Whatever allowance we make, therefore, for undulations of the beds, we must necessarily suppose a very considerable thickness

to interpose between the bottom of the red marls and the bottom of the pebble beds. If, however, we pass on to the east side of the Lickey quartz ridge, we shall find the natural boundary of the red marls coming up within a mile of the older rocks, and near Kendal end, within 100 or 200 yards of them. As the beds do not seem to have any greater amount of dip on the east of the quartz ridge than they have on the south-west, we must either suppose the whole of the red sandstone to have thinned out here, or a very considerable downthrow fault to traverse the east side of the quartz ridge. Moreover, the thick pebble beds lying on the south-west flank of the quartz ridge cannot be traced round its southern extremity, nor seen anywhere to the eastward. It is probable, therefore, that they are concealed under the other beds there by means of such a downcast fault. Several other faults have been found affecting the margin of the red marls, as may be seen in the map.

We have already mentioned a south-west and north-east fault, supposed to start from the sides of the quartz ridge near the coal-measures, and run to the north-east. This has a downthrow to the south-east, and brings down the New red sandstone level with the ends of the Silurian, Coal-measures and Permian beds, between the Colmers and Mason's Lodge. Farther to the north-east it brings the red marl down against the lower part of the new red, namely, the brick-red sandstone, and it then runs off to the north-east through Birmingham, up nearly to Sutton Coldfield, bringing the red marls down against various parts of the New red sandstone. From the eastward of Sutton Coldfield the red marls stretch to the northward uninterruptedly to those before mentioned, north of the Trent, between Barton-under-Needwood and Abbott's Bromley.

The New red sandstone included between this marl boundary and the coal-field consists of brick-red sandstones near Birmingham, lying either horizontally, or dipping very slightly to the east, and allowing of the outcrop of a thickish band of pebble beds that usually form the boundary of the New red towards the Permian district. These pebble beds may be traced, more or less continuously, from the Lightwoods near Harborne to Barr Beacon. They apparently extend eastward

a good way about Sutton Park, but they approach the boundary of the coal-field again about the Brown Hills, and coming against the fault are cut off by it, dipping north under the upper part of the New red, and only just rising up and reappearing at the surface on the high ground west of Brereton, from which place they join on to those of the north part of Cannock Chase. Between Lichfield and Rugeley we have only the upper parts of the red sandstone, those lying just below the red marls as before described; so that if the ground were a little higher, the tops of the hills would all be capped by the red marl, as is the hill at the Old Lodge.

CHAPTER III.

The two previous Chapters have been confined almost entirely to the description of facts actually observed. In the present Chapter some remarks are intended to be made on several points, both practical and theoretical. These remarks will admit of being grouped under two heads: 1st—On faults; 2nd—On the origin of coal.

1. *On faults.*—The word "fault" is one of several that have been selected by geologists from the language of practical miners, and adopted as scientific terms. Various synonyms for it are used in different districts. "Dyke" is the word most commonly used in the north of England, and "trouble," "slip," and other similar terms, often occur. In South Staffordshire the word "thing" is very commonly used instead of "fault." They speak of an "upcast" or "downcast thing."

I am not exactly aware how far "fault" and its synonyms may be used accurately in other mining districts, but in South Staffordshire both "fault" and "thing" are terms which are used by colliers, ground bailiffs, agents, and all concerned with them, in the most vague and puzzling way. These terms are applied to matters of the most incongruous natures, so incongruous that it is impossible to include them under any one general term without introducing great confusion of ideas, and consequently falling into all sorts of blunders in practice.

For instance, we have already seen that a cake of sandstone included in a mass of coal is called a "fault," and though in the preceding pages it has always been spoken of as a "rock-fault," yet that limitation or specification of its nature is not one commonly used in the district. Again, the "rolls" or "swells" in the floor of the coal are called "faults." Mere partial and irregular thickenings or thinnings of a bed are spoken of as "faults." I have even heard the natural outcrop of a bed of coal at the surface, especially if it rose to the crop a little more

suddenly than usual, spoken of as "the fault" by many old miners of the district.

One of the most eminent and long experienced coal and iron masters of South Staffordshire gave, as his definition of a fault, on a legal examination, "anything which interrupted or deteriorated the coal." Under this definition dykes and intrusive masses of "green rock" (or trap) would be called faults.

A very intelligent ground bailiff once described to me a "sand fault," which I could not understand till I found it meant the outcropping of the New mine coal into a mass of drift at a depth of 90 feet below the surface.

Not only do they call "faults" things such as those above, but I have on several occasions had true faults, such as the Brockmoor or Corbyn's Hall fault, described to me as "not really a fault, but only *a slip*."

Examples of the great pecuniary loss and practical blunders likely to arise from this confusion of ideas might be easily accumulated. I will select two. In the case of the gap in the Thick coal at the Gower colliery, described in page 180, it is clear that whatever cause it was which destroyed the coal, that cause had ceased to act before the Cat heath, or the bed immediately above the Thick coal, was formed; yet the ground bailiff who described it to me was surprised that the fault did not affect the Brooch coal 150 feet above the Cat heath. He, knowing that true faults, when found in one bed, must necessarily affect all the beds above it up to the surface, and looking upon this gap in the Thick coal as a fault, expected to meet a similar gap in the Brooch coal above. He of course, would never have recommended therefore any operations in search of this Brooch coal; and much of it might have been left behind if it had not been worked in the adjoining ground, and gradually followed by him over this space against his preconceived opinion as to the possibility of its occurrence.

Another case was a dispute between two gentlemen arising from the uncertainty as to whether "rolls" or "swells" could be considered faults or parts of faults, which involved an expenditure of several hundred pounds, and left the question still undecided.

A. let to B. the Thick coal under a certain tract of ground. This ground was known to be traversed somewhere by a large fault, although its exact place in the ground was not known. The Thick coal was to be got, at a rent of so much per acre, up to the fault wherever it might be, allowance being made for so much of the coal as was injured or diminished by the fault, or by *any branches or offsets of the fault.* It was found, that in addition to the fault, the Thick coal was traversed by two "swells," "rolls," or "horse backs," (see ante, p. 186,) which ran side by side across a part of the ground diminishing the thickness of the coal by cutting out a certain portion of the lower beds of it. These "rolls," or long ridges, were traversed obliquely by the fault, and it was contended by B., that they were *branches or offsets of the fault,* and he claimed compensation accordingly.

A., however, contended that they had nothing to do with the fault, that they were mere ordinary accidents to be expected now and then in coal mining; and if compensated for at all, were to be so on totally different grounds from those put forward by B.

There can be no doubt that if we construe the agreement technically, according to the only possible accurate definition of the terms, A. was right. It is clear that the "rolls" or "swells" existed before the deposition of the upper beds of the Thick coal, while the fault was produced not only after the deposition of those beds, but subsequently to the formation of the whole of the Coal-measures above them. The "rolls" were traversed by the fault just in the same way as all the other parts and portions of the whole formation were traversed by it, and as they existed long prior to the fault, clearly could not have been produced by it, or be anything like "branches or offsets of it." Owing, however, to the vague and uncertain use of the term fault, which is the "custom of the country," and the confusion of ideas in men's minds as to the real nature and origin whether of beds or faults, as much evidence, and from as respectable parties, was adduced on B.'s side as on A.'s, and the matter was ultimately compromised.

This matter is mentioned here thus prominently because it is

clearly a practical point well worthy the attention of those engaged in all coal mining operations. Unless such common terms as that of "fault" can be assigned a definite technical meaning, it is plain that their insertion into legal documents, agreements, &c., can only be the fruitful cause of error and dispute, leading to much useless expense, and possibly to much needless ill feeling.

The remedy for the correction of error both in practical operations and in legal agreements, depending on the proper understanding of the nature of faults, is obvious. It is that the ground bailiffs, mine agents, and surveyors, the men on whose word and authority these things mainly depend, should have the opportunity of acquiring larger and more accurate knowledge, and more correct ideas, as to the real nature of the matters they are engaged with. A comparatively slight acquaintance with the rudiments of practical and theoretical geology, such as might be acquired by any intelligent person from a few months instruction from a competent teacher, would be sufficient to produce a perfect uniformity in all such men's opinions as to what was and what was not "a fault." Such instruction would enable every mine agent in future life to observe accurately, and to arrange and record his observations truly and methodically, so that all his subsequent experience would be applied in the right direction, instead of, as is too often the case, in the wrong one, and tend to increase his real knowledge, not to add to his misconceptions.

The South Staffordshire coal-field has been so thoroughly worked and explored, that a study of its faults and dislocations will add something of precision and completeness even to the knowledge of a professed geologist.

It is clear that a single fault, that is, a fissure running along one straight or slightly curved line, can only produce a "throw" or dislocation of the beds along *a part* of its course. There must be a point where the dislocation begins, from which it increases to a maximum, and another point where it gradually ends. Such a fault may be likened to a crack in a deal board which ends in the board each way before it reaches its extremity. It is evident that we can only elevate or depress a portion of

the board on one side of the crack above or below the corresponding portion on the other side by pushing it in or near the centre of the crack, and causing that portion to bulge. The protuberance of the bulge will be greatest at this part, and gradually diminish each way to the points, where, though the crack may continue, the parts on opposite sides of it retain their relative position. Such "single-lined faults" are those that extend east and west across the part of the coal-field between Dudley and Bilston. Although single in the centre of their course, they often split into one or two small branches near their extremities. The dislocation may be increased by the measures on one side of the fault being bent up into a bulge along its course, while those on the other are bent down. We may, moreover, conceive it possible for the beds ranging along the fault to have more than one "bend" in them, and thus the amount of the throw to diminish and again increase; and if the beds on opposite sides of the fault bend in opposite directions, the flexures may cross each other, and thus the fault apparently disappear, and again set on again along the same line.

If now, recurring to the deal plank, we were to make a cross cut to the crack before mentioned, it is obvious that by applying the requisite force near the junction of the two, we might permanently elevate or depress the included corner of wood. We should then have a representation of two faults, each increasing towards their point of intersection. Or if we continue the crack to the edge of the plank, which we may look on as a great boundary fault, we may bend one side so as to make the dislocation gradually increase from its commencement up to its termination. Of the latter case we have examples in the Corbyn's Hall and Buckmoor faults, that gradually increase their "throw" as they approach the western boundary fault.

It follows from the above considerations, that if there be only one or only two lines of fracture they must gradually diminish and end somewhere, and that the dislocated ground must have one place of maximum disturbance towards which *it bends down* either in one or several directions.

To have any piece of ground altogether elevated or depressed with regard to the whole of that surrounding it, it is necessary

that it be bounded by at least three rectilinear faults, or by such an arrangement of curved fractures as amount in effect to three or more rectilinear ones.

These statements will, of course, be to the geometrician exceedingly simple, and scarcely worth making. The considerations involved in them, however, are sometimes hardly sufficiently attended to in geological surveying. One often sees a mere straight line representing a fault on a geological map, and one sometimes is tempted to wonder what becomes of it, or how any mass of beds can be elevated or depressed in consequence of a single crack running through them. That such single-lined fractures do occur, however, the beds on one side bending down, while those on the other have remained stationary, or have perhaps bulged upwards, is proved by the occurrence of the east and west faults, before described, traversing the South Staffordshire coal-field.

The above considerations have to do with the longitudinal extension only of faults, but their vertical extent is equally worthy of study. This, however, is so wide a field, that we shall only venture on a small portion of it, the subject of "Trough faults," and refer the reader for other parts of it to the papers of Mr. Hopkins in the "Cambridge Philosophical Transactions," vol. 6, and in the "Philosophical Transactions of the Royal Society of London," vols. 133 and 134, 1842-3, as also to a paper by Mr. Darwin, in the "Transactions of the Geological Society," vol. 5. p. 601.

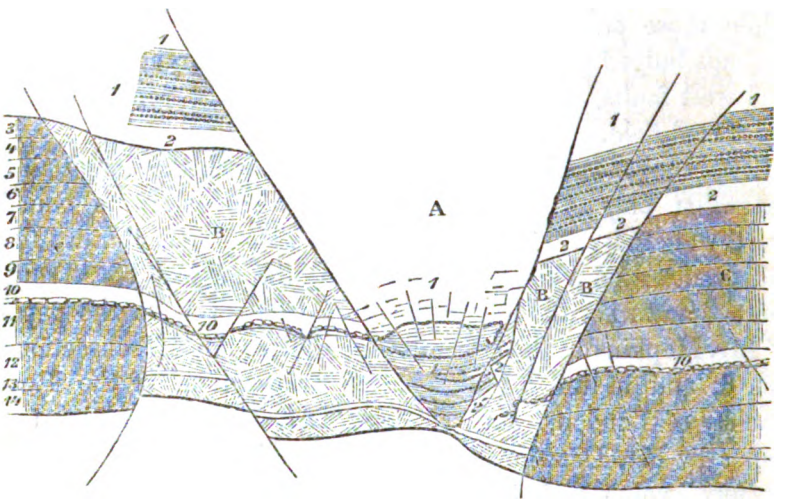
Of "Trough faults" we have several excellent and well-explored examples in the South Staffordshire coal-field, both on a large and small scale. We will take for examination one example of each, namely, the Dudley Port Trough faults for the large scale, and a small pair of faults in the Victoria colliery, West Bromwich, for the other.

The Dudley Port Trough faults are shown in the section given in this volume (a reduction from No. 7, sheet 25, of the Horizontal sections), and their general form is reproduced in fig. 15. They have previously been described (p. 278), to which the reader is requested to refer.

Mr. H. Johnson of Dudley, in the year 1849, showed me in

his office a carefully-executed drawing of a singular appearance he had observed in the Thick coal in one of the gate-roads of the Victoria colliery at West Bromwich. At this spot the lower beds of the Thick coal were apparently unbroken and regular, but in the three upper beds there was a trough-shaped gap, 8 feet wide at bottom and 15 feet wide at top, in which reposed a corresponding mass of the beds that on either side lay on the topmost bed of the Thick coal. This gap in the coal gradually descended in one direction till it reached the bottom of the Thick coal, and assumed the form represented in the following figure :—

Fig. 13.



Scale, 1 inch equal to 20 feet.

A. Trough-shaped gap in the Thick coal.
B. and C. The Thick coal.
1. Shale and clunch above the Thick coal, containing some bands of ironstone nodules.
2. A black batt (bituminous shale).
3. Roofs. } Thick coal.
4. Top slipper.
5. White coal.
6. Lambs.
7. Tow coal.
8. Brazil.
9. Foot coal.
10. Hard stone parting.
11. Stone coal.
12. Sawyer and slipper.
13. Bench batt.
14. Benches coal.

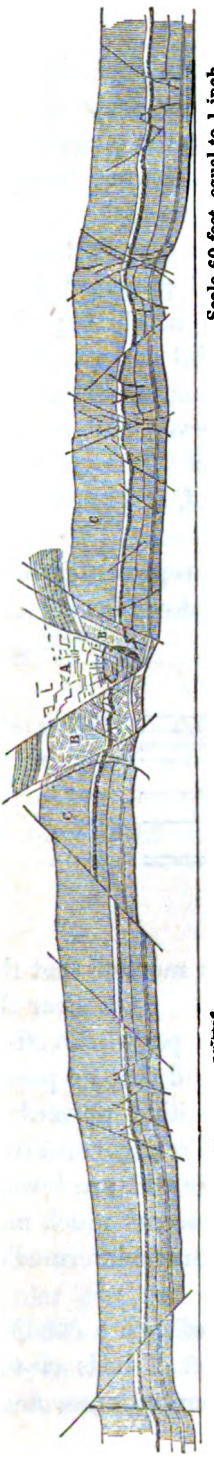


Fig. 14.

The triangular gap A in the Thick coal is filled up by a corresponding portion of the beds above the coal, consisting of shale and clunch, the lower part of which contains several courses of nodular ironstone, marked 1 in the figure. The strata in A are said to be "much broken and contorted, especially towards the apex. The ends of the strata are turned a little upwards. Two pieces of bituminous shale (2) should under ordinary circumstances occupy the top of the coal." These latter are shown near the right hand of the bottom of the trough in the figure, and marked (2). The trough traverses the coal in a north-east and south-west direction, the bottom of the trough forming an angle with the horizon of 4° 30′.

In the portion of the Thick coal marked C, the lamination and stratification of the coal is uninjured, but in the part marked B, while the stratification is for the most part probably unaltered, as is shown by the "partings" 10 and 13 continuing through it almost uninterruptedly, the "lamination of the coal is totally destroyed, and the coal has the appearance of a paste made up of coal dust and very small coal. It appears to have attained its present consistency from compression and not from heat."*

Fig. 14 is a more extended representation of a side of the same gate-

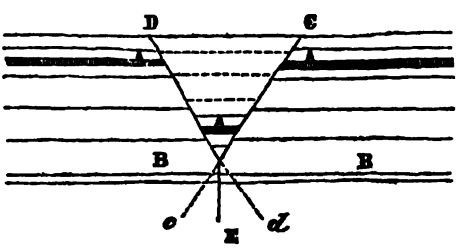
* Mr. Johnson's notes.

road on a smaller scale, that of 60 feet to the inch, its total length being about 150 yards. It is reduced from a much larger drawing of Mr. Johnson's, which was drawn to scale from very careful measurement, every fissure and flexure being as nearly as possible exactly represented.

The two drawings given in figs. 13 and 14 were taken, I believe, in consequence of the explanation I proposed to Mr. Johnson, to account for the appearance mentioned first (p. 312), that in which the trough did not end in a point downwards, but was still 8 feet wide at its base. The explanation then given was fully confirmed by these facts since observed and recorded by Mr. Johnson; and as it is applicable to all "Trough faults," and bears on the question of faults in general, it is now given here.

The simplest form of a Trough fault is that represented in fig. 15, in which a portion of the bed A is dropped down between two

Fig. 15.

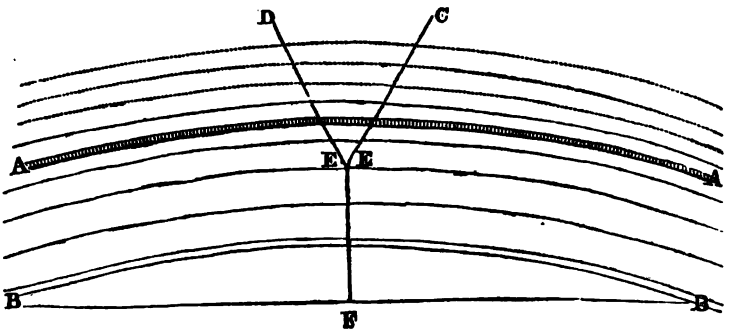


equal faults, C and D, which incline in such a manner that they must meet before reaching the lower bed B. It is clear that these faults, having an equal "throw" in opposite directions, must when they meet neutralize each other, and that no portion of the bed B can be "thrown" by them either upwards or downwards, or in any direction whatever. We may conceive it possible, however, that C may be continued as a fissure towards *c* or D similarly continued to *d*, though it seems much more likely that they should coalesce and continue in one intermediate fissure E.

The most obvious explanation of the cause of such a condition of things seems to be the following. Let a set of beds of rock of indefinite extent, among which are two marked ones, A and

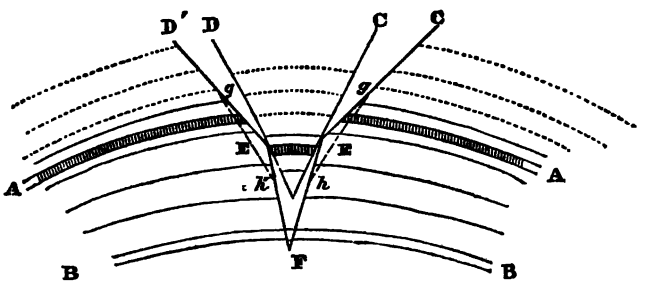
B, be acted on by an elevating force from below, causing them to bulge upwards as in fig. 16. Mr. Hopkins has shown us that if this expansion be continued far enough, the result will be the production of one or more longitudinal fissures, commencing at some point *below the surface*. Let such a fissure be produced running from F to E, and at E let it split into two, E D and E C.

Fig. 16.



Now, if the expansive force be continued, and a consequent further elevation take place, it is clear that the beds will assume the further form shown in fig. 17, the two side portions being still more bent upwards, and the fissure consequently gaping

Fig. 17.



open, so that the lower single fissure F E widens into a triangular gap, and consequently E C spreads to E C′, and E D to E D′. In this case the included triangular mass of beds between D and C must fall down into the open fissure F E. Moreover, as for every inch that the parts A B rise and that

E F widens, the included mass D C will settle down into it, the corners at E will be worn and ground down by the friction, so that they will very shortly be ground off to the lines *h g*, which will have the effect of still further widening the fissure, and consequently of admitting the wedge-shaped piece D C to sink further down into it.

Suppose now that the expansive and elevatory force ceases to act, and the upraised beds begin to settle down again towards a horizontal or nearly horizontal position, it is quite possible for the lower part of the fissure E F to close again, and to close in some cases so accurately and perfectly, that if the beds are at all soft and cohesive, scarcely a trace of it may be left after some period of compression. That part of the fissure, however, into which the wedge has sunk will, of course, not be able to close again, but it will strive to do so, and great force of compression will consequently be exerted on the sides of the wedge, and on the beds which come against them. The effect of this compression is shown in fig. 13 in the destruction of the lamination in the coal marked B B. As, however, the beds sink into a very low arch, the downward pressure is in great part transferred from the wedge, which we may look on as its keystone, to its abutments, the parts A and B on the sides of figs. 16 and 17. When the arch becomes very low, the pressure hereabouts must be enormous; and it is important to remark,* that we have here a real cause for bonâ fide *lateral pressure*, and consequent lateral shifting, and even of the sliding of one bed over the other, so that during the subsidence greater dislocations and more crumplings and contortions may take place at the end of the arched beds, or at some distance outside of them, than took place in any part of the beds during the action of the elevating force.

Fig. 14 is an admirable instance of the arched condition of the beds, of the compressed central parts B B, and of the cracks and fissures that are likely to be caused on the sides of the arch as the beds sink down again and are endeavouring to adjust

* This was remarked to me by Mr. Hopkins, in a conversation I once had with him on this point in the Museum of Practical Geology.

themselves to their altered condition, consequent on the intrusion of the wedge A.

As all these actions will be taking place in nature simultaneously and very irregularly, according to a multitude of varying conditions, we may have a great number of modifications of the simple action here described. Among other things we may easily imagine the apex of the wedge to suffer considerably in some places, and to be ground off till it may have a blunt base, not only of 8 feet, but of many yards in width.

I have spoken before of the benefit Practical Mining might receive from the study of the science of Geology. This case is an instance of the great reciprocal advantage the science of Geology would receive from the observations of practical miners, if they knew what to observe and how and where to record their observations. In the matter of faults and dislocations in the Coal-measures especially, there are many curious observations yet to be made, and many cases occur that would at first puzzle a geologist, and might be deemed by him impossibilities till he saw them before his eyes. Some of these came partially and imperfectly under my own observation when surveying this coal-field, but they could only be properly described and recorded by a person who was frequently engaged in measuring and drawing them during the progress of works extending, perhaps, over weeks or months.

We may, perhaps, here advantageously say a word or two as to the age of the principal faults and dislocations of the South Staffordshire district.

It is clear that, however the Silurian rocks may have been partially disturbed and denuded before the deposition of the Coal-measures, none of the prominent dislocations and disturbances which give the marked features to the structure of the district, took place till after the formation of the whole of the Coal-measure series.

How far the pre-existing rocks were fractured and disturbed at the *commencement* of the Permian period, or during the interval between the deposition of any Coal-measures and that of any Permians, is also difficult to be determined.

From considerations partly derived from this district, partly from other portions of the Midland Counties, it would appear probable that great disturbances, producing both large dislocations and an immense amount of denudation, took place some time *in* the Permian period, or some time between the period of the Coal-measures and that of the true New red sandstone. I should incline to look on it as possible that the disturbances along the line of the Lickey and Dudley and Sedgley anticlinals are of this date, and possibly also some of the principal faults of the coal-field. It is, however, plain, from the description given in the last chapter, that the great boundary faults of the coal-field were, if not produced, at least largely acted on subsequently to the deposition of the whole of the New red sandstone, and even to that of the Lias. It is, of course, quite possible that the first impulse towards these faults, the strain that produced the cracks, was communicated to them at the period when the great disturbances in the carboniferous rocks took place generally through Britain; and that period seems certainly to have been previously to the existence of the New red sandstone. A further subsidence or elevation, in other words, a relative displacement, may have at some subsequent period, or even at several periods, taken place along these cracks, extending them into the more recently deposited beds of the red marls and the Lias, and "throwing" those rocks up or down from their original level, as we see to be the case with the red marls on both sides of the coal-field, and with the Lias south of Bromsgrove.

No one, I think, will now be able to look at a geological map of the centre of England, without connecting in his mind's eye the Lias of Worcestershire and Warwickshire with that of Staffordshire and Cheshire, and being convinced of their having once formed one broad connected sheet, a level plain of Lias spreading over all the intervening districts and sweeping up into the borders of Wales. Wherever a sufficient thickness of the upper red marls has been left undenuded, to render it possible for beds of Lias to come in, there we find them; but for the denudation, therefore, we should have found Lias wherever we now find the red marls. The same reasoning will apply to the

several members of the New red sandstone, down to the base of that formation. Wherever, therefore, the New red sandstone spreads (in the Midland Counties, at all events), it was in all probability once covered by Lias.

At all events, it is clear from our previous descriptions, and from an inspection of the maps and sections, that before the production of the dislocations of the great boundary faults, the New red sandstone spread over the coal-field and whole district of South Staffordshire, and we can see no reason why it should not have had the whole of its beds everywhere, or why these beds should not have been everywhere covered by the Lias.

At some subsequent period great dislocations took place, and either the present coal-field was lifted up above the surrounding district, or it was left standing while the surrounding districts were depressed, and thus rising as a great protuberance, was of course subject to the more marked influence, and more complete action, of the denuding agencies which have worn and pared down all the country to its present surface. In this way the lower rocks have been stripped of their former covering in the district forming the present coal-field, while more or less of that covering, according to circumstances, has been left untouched in the surrounding country.

The practical bearing of these remarks is, that wherever we find any of the upper formations, we shall there, in all probability, find all the inferior ones in their proper position below it. To commence sinking for coal, therefore, in any of the parts coloured as red marl in the geological maps of the Midland Counties, would be only to throw away money; still more absurd would it be to attempt to find it by sinking in the Lias, as was formerly tried on Needwood forest.* It would even be still a very imprudent speculation to attempt to sink for coal within a

* I may, perhaps, be pardoned for saying here, that even within my own recollection, since the year 1830 for instance, more money has been foolishly expended in the abortive search for coal alone, in places where a geologist would have at once declared against the possibility of finding it, than would have paid the entire cost of the geological survey from its commencement to the present time; or its future cost for many years.

great part of the New red sandstone district, until those parts coloured as Permian have been more fully examined and explored, and the possible and probable thickness of the Permian rocks ascertained.

Supposing any one to be desirous of sinking for coal, either in the district between the South Staffordshire and Shropshire, or between the South Staffordshire and Warwickshire coal-fields, and assuming that Coal-measures stretch without interruption beneath, an assumption which the exposed area of the district described would not warrant, he will have to calculate—

1st. The probable thickness of the beds of the New red sandstone he will have to pass through.—This will, in many places, be several hundred feet, let us say 500.

2d. The possible or probable thickness of the Permian formation.—We have seen reason to suspect that this is in some places, perhaps in many, at least 500 yards, or 1,500 feet in thickness. He might be lucky enough to hit upon a spot where there was none of this; but there would be a great chance against such a piece of good fortune, and he would only act wisely to set this rock down as 1,500 feet thick.

3d. The probable thickness of the upper and unproductive Coal-measures.—We have seen that in some part of the South Staffordshire coal-field there are 900 or 1,000 feet of Coal-measures above any of the workable beds of coal or ironstone. Our supposed speculator then would, in any place, have a great chance of coming first upon these upper measures, and would do well to calculate on the possible occurrence of 1,000 feet of them before he reached the more profitable beds.

We thus get altogether a total of 3,000 feet, or 1,000 yards, for the probable depth of good workable Coal-measures over the greater part of the space between the South Staffordshire coal-field and those of Shropshire on the one hand, or that of Warwickshire on the other, under the supposition above mentioned.

2. *On the origin of coal.*—Coal is universally allowed to be of vegetable origin; it is a mass of the débris of trees and plants, that having been buried under mud and sand, has been subsequently converted into coal, the muds and sands being similarly

converted into shales, and clays, and sandstones. There are, however, two opinions as to how the vegetables got into the situation we now find them in. The first, and at one time the more general opinion was, that trees and plants were drifted into large lakes, estuaries, and shallow seas, and there becoming water-logged, sank to the bottom, and were subsequently covered up there by the other accumulations. The second opinion, and perhaps the most generally entertained now, is, that the plants entering into the composition of the coal were not drifted, but grew and perished on the very spot we now find them, just as our own peat bogs at the present day would form coal if buried for a vast series of years under a great accumulation of earthy matters.

Now botanists tell us that all the plants entering into the composition of coal, so far as they have been able to trace and verify any part of their structure, appear to have been not aquatic but terrestrial plants. For the formation of the beds of coal, therefore, *in situ*, it is necessary to suppose that the water in which the shales and sandstones were deposited became filled up, and the space converted into dry land, or, at all events, into a marsh at or above the level of the water; that on this dry land or marsh, plants accumulated in sufficient quantity to form a bed of coal; that then a depression took place, and the space became again covered by water, in which more shale and sandstone materials accumulated, again filling it up to the level of the water, and then another marsh, and so on.

I by no means intend to range myself among the advocates of either one or the other opinion, but I think there are certain difficulties in the way of the latter, which in spite of all the evidence as to the roots* and upright stems of trees, (or whatever the plants called Sigillaria, Stigmaria, &c. may have been,) would make me hesitate to embrace it exclusively. Some

* Among other evidences is the case described by my friend Mr. Beckett, of Wolverhampton, in the first vol. of the Geological Journal. I accompanied him to the open work at Parkfields, where these stumps of plants occurred in the coal. They certainly looked as if they had grown there, and perhaps they may have done so, but even so, it by no means settles the whole question.

of these difficulties arise from facts observed in the South Staffordshire coal-field, and these it is now proposed to lay before the reader.

1st. The "rolls," "swells," or "horses backs."—We have seen, page 186, fig. 6, that these are long ridge-like accumulations of clunch or clay rising for sometimes at least 8 feet above the floor of the coal around them. If they were accumulated under water, but the surrounding coal was begun to be formed at or above the level of the water, we must necessarily suppose an elevation of the ground to have taken place to the amount of 8 feet, between the time of the formation of the "swells," and that of the coal, or else that they were formed during seasons of flood when the waters were 8 feet higher than usual. The structure of these "swells" seems to me a very small foundation on which to build the hypothesis either of a partial 8 foot elevation of the land, or for an 8 foot rise of the water, which must have been general over all the United Kingdom.*

2d. The phenomenon of the Flying reed. — If the reader will turn to page 177, fig. 3, he will see that to account for the structure there described, on the principle of all coal-beds being of terrestrial growth, the following suppositions are necessary: Firstly—the water was filled up to its surface, and on that level plain the Heathen coal was formed, then a depression took place and a subsequent refilling of the water, and then the Thick coal was formed. When, however, the accumulation of the vast quantity of vegetable matter necessary for the production of the Thick coal was nearly completed, a very partial and local subsidence took place in one or two localities, bending down the previously formed beds into a hollow or pool of water, sufficiently deep for 128 feet of shale and sandstone to be accumulated, and thus another level floor formed for the growth of the upper bed of coal which grew partly on the shale and sandstone, and partly on the undepressed coal. Then another depression took place, which was itself very unequal, and had this peculiarity, that

* That is, supposing all the Coal-measures of the United Kingdom at least to have once been continuous, a supposition which appears an almost inevitable one.

over the part previously depressed it only amounted to 38 feet, while over the part not so depressed, and over the district generally, it was from 120 to 180 feet.*

Again, the production of the Thick coal itself, that is to say, the formation of 12 or 13 beds of coal amounting to 30 feet, with little or nothing between them over a particular locality, while outside that locality they are variously split up, and interstratified with many beds of shale and sandstone, involves, on the "alternation of land and water hypothesis," the supposition of such a complicated machinery of unequal and local elevations and depressions, while a central piece of ground was remaining stationary, that I confess I should hesitate to believe it necessary.

3d. The rock faults in the Thick coal.—These were described, page 184, figs. 4 and 5. The most obvious questions to put respecting them, when we are inquiring into the origin of coal, are, if the sandstone was deposited in water, and the coal is so intimately and minutely interstratified with the sandstone, how comes it that the coal was not itself deposited in water? or, if the coal is of terrestrial origin, must not the sandstone be so too? The only possible origin† for the sandstone I can imagine on the latter alternative is, that the sand was brought up in among the vegetable matter by means of a strong spring or springs, but whether such an imagination be allowable to account for a mass of sandstone 250 by 400 yards in extent, at least, must be left to the decision of the reader. There is, perhaps, an almost equal difficulty in understanding this local accumulation of sand over a comparatively small area, surrounded by so much almost unmixed coal, on the supposition of their both being drifted into the place we now find them, and deposited under some considerable depth of water, but in this case it is nothing more than the

* It seems necessary to suppose that the depressions were unequal, and the irregularities levelled up to the surface of the water, by the accumulation of materials, because, if the depressions were equal over large spaces, and the accumulations of unequal thickness, we should be obliged to call in the aid of unequal elevations or depressions again, to form a level surface "à fleur d'eau," for the growth of the next bed of coal.

† It is clearly impossible it can have been "blown" sand.

local occurrence of a cake of sandstone among wide spread beds of clay, or other material, a case which we know frequently occurs in nature.

The structure of coal in general, its regular lamination and stratification, and the many thin widely spread partings of clayey or sandy matter between its several beds, all putting one so strongly in mind of the characteristics one is accustomed to consider positive proof of the tranquil deposition of the materials possessing them, beneath pretty deep water, have to me always been great difficulties in the way of accepting the terrestrial origin of coal; but as these are common to all coal-fields their mention is all that can be allowed in a memoir dedicated to one district in particular.

THE DRIFT OR SUPERFICIAL ACCUMULATIONS.

I have reserved to this place the little I have to say on this subject. This little consists of a few fragmentary notices rather than any connected account.

Blocks of granite and old trappean rocks, evidently belonging to the Great Northern drift, are found in great abundance all along the western boundary of the coal-field, especially about Bushbury, and thence towards Cannock. They occur abundantly also over all the New red sandstone country on the west of the coal-field. They may be found occasionally, but by no means abundantly, within the limits of the coal-field itself, but on its eastern side they are, as far as my recollection serves me, comparatively very rare. They are seldom found embedded in any great mass of drift matter, but lie for the most part loosely scattered over the surface of the country.

There is another set of drifted materials which I should be inclined to separate from the Great Northern drift, because large granite blocks are rarely, if ever, found in it, while it often abounds in chalk flints, and sometimes in broken fossils of the Lias and Oolitic formations, and seems, therefore, rather to be derived from the east than the north. This occurs in the shape of sand and gravel lying in patches here and there about the

district, or sometimes as a red clay. Red clay, containing water-worn Lias fossils, is frequently found about Wolverhampton, or between that town and Shiffnal, on the cutting of the Shrewsbury railway, resting on the New red sandstone. A block of galena, also, as big as a man's head, was once procured from it near Wolverhampton. It never has been found, so far as I am aware, to contain any fragments of arctic shells, or of any other shells or fossils than those before mentioned as drifted out of other formations.

There is yet another class of drift, apparently distinct from both the above, as never containing any granite or northern boulders, nor any water-worn fossils or recognizable fragments of other formations. It consists, for the most part, of very fine red sand, with a few occasional lines or thin beds of very small well-rounded pebbles, principally of quartz or quartz rock. This occurs in immense quantity about West Bromwich and Hill top, in places between Darlaston and Walsall, and thence towards Willenhall and Pelsall. Large and deep excavations in it may be seen at Moxley Sand holes,* between Wednesbury and Bilston, whence it runs in a pretty well defined band, about a quarter of a mile wide, up to Marshend, a little east of Wednesfield. It makes no feature at the surface of the ground, but comes in suddenly 50, 60, or 100 feet deep, filling up a pre-existing valley in the Coal-measures, and causing great trouble to those who have to sink through it to the beds below. North-east of Wednesbury the New mine coal suddenly crops into this loose sand at a depth of 90 feet below the surface of the ground.

This loose red sand seems to be the washing of the adjacent New red sandstone, and when it is a little consolidated, which it sometimes is, and only a small section of it is exposed, it is extremely difficult to distinguish it from undisturbed New red. This is especially the case about Pelsall and Pelsall Heath. I should class with this drift, in time and manner of accumulation, those quartzose gravel beds which do not belong to

* Some men working in these sandholes assured me that a stag's antlers had once been found in this drift at a depth of 40 or 50 feet below the surface.

the New red sandstone, but which are derived from the washing of its "pebble beds" or conglomerates. These occur very abundantly in some places; they were well shown formerly in the deep cutting of the canal at Smethwick. They spread over all the southern part of Cannock Chase, resting on the Coal-measures there, having been brought probably from the undisturbed pebble beds or conglomerates of the New red, which form the northern portion of the Chase.

Whether these three sorts of drift all belong to one and the same period, that commonly known by the name of the glacial period, is a problem yet to be solved. I may be pardoned, perhaps, for saying that I think many geologists are too hasty in speaking of all superficial drifted materials as "*the drift*," as if there could only be one drift. We have already seen that there was both a Permian and a New red sandstone drift, portions of which, when they appear isolated at the surface, would be taken by any one for parts of the "glacial drift," at first sight.

I know of no reason, for instance, why the drift clay, and sand and gravel containing Chalk flints and Lias fossils, might not be of the age of the gravels of the Plastic clay, though I am not at all disposed to assert that they are so, because, as I know of no evidence against such supposition, neither do I know of any reason for it.

If it be true that stags' antlers were found under the red sand at Moxley, it would, of course, be a proof of its comparatively recent origin; but in the absence of that or some such proof, I should hold myself prepared to find that these sand and gravel washings of the New red sandstone were of any age from that of the Oolites down to the Pleistocene.

CONCLUSION.

No one can be more sensible than myself of the deficiencies of the preceding pages. The work was executed on the Ordnance Map of the scale of 1 inch to the mile, there being no other of similar accuracy on a larger scale. A more detailed survey might have been made had there been a map on the scale of 6 inches to the mile, such as that of the Townland Survey of Ireland (by the aid of which the geological survey of Ireland is carried on), or the similar map now in progress in the north of England. Such maps show every natural and artificial feature on its proper scale, and leave room for the insertion of all the requisite data in a distinct form, and without any distortion.* With such a map it would have been possible to have had a separate survey of the Thick coal, showing its depth below the surface at any locality, the nature and magnitude of the faults traversing it, and the extent of injured coal or barren ground caused by them; the places where the coal was injured by trap rock, and the amount of the damage; the districts, such as the large swamp in the centre of the coal-field, where it is now under water, the probable area and depth of that water, and consequently the power necessary to drain it; the spaces over which the Thick coal has been either partly or wholly extracted, and those where it is still untouched; and all other needful and useful information respecting it might thus have been brought together in a compendious form of the highest importance and utility to the practical miner. Every other important bed of coal and ironstone could have been laid down on its separate map, showing its extent, depth, thickness, richness, and the places where it had and where it had not been gotten.

* After a year and a half's experience in working on the 6-inch map of Ireland, I can speak authoritatively as to the importance and value of such a map for geological surveys.

Every one who has had anything to do with coal mining, even as a spectator, must be aware of the great waste of money, labour, and materials, consequent on the division of property among many small owners, each having different and opposite interests. Were the South Staffordshire coal-field now untouched and the property of one individual, there is no doubt that, as far as the mere economical extraction of its minerals is concerned, it might be worked under one well-considered system with infinitely less cost and far greater profit than it has been. The subdivision of property has, of course, great advantages on its side to counterbalance this disadvantage; but the carrying out such a survey as that I have named, while it would not at all interfere with the advantages arising from the subdivision of property, would render it possible to avoid all or most part of the disadvantage, because every one would know the exact state of the ground around him, and mutual agreements might thus be entered into as to the time and method of each working his own piece of land to the best advantage.

In the meanwhile it is hoped that the present general survey of the South Staffordshire coal-field will be found of considerable practical utility, since it has enabled us to combine into a general view much information that had hitherto been only scattered piecemeal about the district, to give a little more definite and common direction, perhaps, to the ideas hitherto floating loosely in many men's minds, as also to warn men off the districts where costly speculations will be almost sure to be unrewarded, and in some degree to point to those where they are most likely to be successful.

In conclusion, I have to make my acknowledgments to my many kind friends in South Staffordshire for much assistance, without which the survey could never have been rendered so accurate and complete even as it now is. I never made a single application to any landowner, coalowner, or ironmaster of the district, or to their agents, ground bailiffs, and men of business, for any species of information, that was not instantly and courteously responded to in the most ample manner. To enumerate the names of persons I have been thus indebted to would be to give a list of a large part of the population of the district; and is

therefore obviously impossible. It is, however, only justice to state, that when the survey of the district was commenced, several of the principal faults traversing it had been laid down on large parish maps by some members of the Dudley Geological Society. Messrs. W. Sparrow and H. Beckett had done this for the district between Wolverhampton, Walsall, and Wednesbury, and Messrs. S. H. Blackwell and C. Twamley for the district around Dudley. The results of their labours were freely communicated, and after being verified are now published in our maps. Several other gentlemen have been mentioned by name in the preceding memoir as having afforded important information, and many more might have been mentioned but that the information they so kindly gave became worked into the general account of the district, and did not relate to any particularly prominent and salient points of its structure.

APPENDIX.

In speaking of the inclination of a bed, or of a fault, or any other plane, it is common in South Staffordshire to describe it by saying how many inches it deepens, or dips, in a yard. In many other districts this is done by saying how many feet or yards it dips or inclines in the hundred. Geologists usually describe the dip by stating the number of degrees of the angle included between the plane of the bed, &c. and the plane of the horizon. It is often very useful in field surveying to know at once, roughly, how these things correspond, for which purpose I wrote out the following table for my own use, and add it here, as it may be useful to others:—

Nearest degree of dip, or each 1 in 100, answering to each inch in a yard.

Inches in a yard.	In 100.	Nearest degree.	Inches in a yard.	In 100.	Nearest degree.
1	2·78	1½°	19	52·82	28°
2	5·56	3°	20	55·60	29°
3	8·34	5°			
4	10·12	6°	21	58·38	30°
5	13·90	8°	22	61·16	32°
			23	63·94	33°
6	16·68	10°	24	66·71	34°
7	19·46	11°	25	69·50	35°
8	22·24	12°			
9	25·02	14°	26	72·28	36°
10	27·80	16°	27	75·06	37°
			28	77·84	38°
11	30·50	17°	29	80·62	39°
12	33·36	19°	30	83·40	40°
13	36·14	20°			
14	39·92	21°	31	86·18	40½°
15	41·70	23°	32	88·96	41°
			33	91·74	42°
16	44·48	24°	34	94·52	43°
17	47·26	25°	35	97·30	44°
18	50·04	26°	36	100·00	45°

When the inclination is greater than 45° it is commonly sufficient to say that a bed, &c. dips two yards in a yard, three yards in a yard, &c. &c.

Now 1 in 1 = 45°
2 in 1 = 63° nearly,
3 in 1 = 71° nearly.
4 in 1 = 76° nearly.
&c. &c.

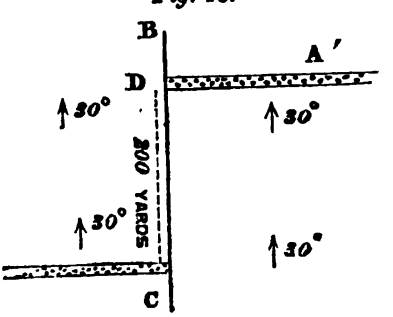
Another table that is often found useful in geological surveying is one that for every degree of dip of a bed, &c. will give its depth from the surface (supposed to be a horizontal plane) at a distance of 100 feet or yards, measured in the exact direction of the dip. In the following table this is given for every degree up to 20°, and for every five degrees after that; and also the thickness of any set of beds thus inclined, measured, not perpendicularly to the surface but perpendicularly to the dip, in other words, the thickness they would have if they were horizontal.

Horizontal distance = 100.

Angle of dip.	Depth.	Thickness.	Angle of dip.	Depth.	Thickness.
1°	1·7	1·7	18°	31·8	30·9
2°	3·5	3·5	19°	34·5	32·6
3°	5·3	5·3	20°	36·6	34·2
4°	7·0	7·0			
5°	8·8	8·7	25°	46·9	42·3
			30°	58·0	50·0
6°	10·6	10·5	35°	70·5	57·4
7°	12·3	12·2	40°	84·2	65·6
8°	14·1	13·9	45°	100·0	70·7
9°	16·0	15·6			
10°	17·7	17·4	50°	119·0	76·6
			55°	143·0	81·9
11°	19·5	19·1	60°	174·0	86·6
12°	21·4	20·8	65°	214·0	90·6
13°	23·2	22·5	70°	275·0	94·0
14°	25·2	24·2			
15°	26·9	25·9	75°	368·0	97·0
			80°	575·0	98·0
16°	28·7	27·6	85°	1,143·0	99·0
17°	30·7	29·2			

By means of this table, also, the probable "throw" of faults can be ascertained, where the broken ends of a bed on opposite sides of a fault can be found, and a certain mean angle of dip assigned to the whole mass.

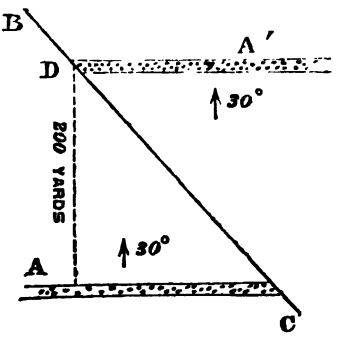
Fig. 18.



If, for instance, fig. 18, there be a set of beds, including one particular bed A A′ dipping at 30° in one direction, traversed by the fault B C running in the direction of the dip, and the ends of the bed A A′ on opposite sides of the fault be any distance apart, say 200 yards, then, inasmuch as the bed A would by the table be twice 58=116 yards deep at D on one side of the fault while it is at the surface of the ground (supposed to be a horizontal plane) on the other side of the fault, it is obvious that the fault B C has a "downthrow" of 116 yards towards D.

If the fault traverse the beds obliquely to the strike, as in the following figure—

Fig. 19.



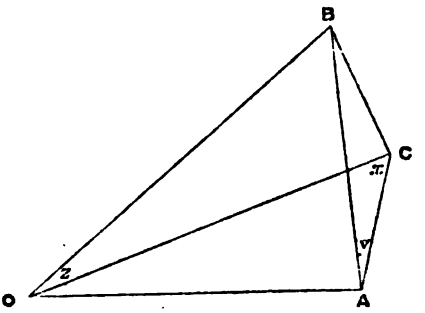
—we must, instead of measuring along the fault B C, of course measure A D along the dip, and then proceed as before.

Although it has no especial reference to the district of South Staffordshire, I would yet take this opportunity of printing and publishing the additional table below.

In the year 1850 we were engaged in running sections across a very contorted district of North Wales, so contorted that it was impossible to contrive any long continuous section that should not in some part of its course cross both beds and cleavage planes very obliquely. It became important, therefore, to know what correction to apply to the observed angle of dip of those beds and planes, so that they should be drawn in the sections correctly with the dips they would actually appear to have in a vertical cliff if one were formed along the line of section. Although the little trigonometry I ever possessed had long grown rusty from disuse, I yet contrived to puzzle out a formula which should express this correction, and from that calculated the table.

Subsequently, however, I lost the clue which had led me to the results, and became doubtful as to their correctness; I therefore applied to my friend Mr. Hopkins, now President of the Geological Society of London, and he, with his usual kindness, favoured me with the following solution of the problem, which I was glad to find gave the same result as that at which I had arrived by a more roundabout and empirical course.

Fig 20.



Let O A be a horizontal line on the surface of a bed, it will be the direction of the strike: O C the direction of the section as given by the compass, O C being also horizontal.

Draw A C in the same horizontal plane as O A and O C, and at right angles to O A, A C will be the direction of the dip as given by the compass.

Draw C B, *vertical*, to meet the surface of the bed in B, and join A B and O B.

The angle C A B will be the real dip, and C O B the apparent dip, of the bed, as seen in the face of the supposed cliff or section.

Let O C A $= x$, the angle which the section makes with the direction of the dip,

C A B $= y$, the real dip,

C O B $= z$, the apparent dip,

$$\text{then } \tan. y = \frac{\text{B C}}{\text{A C}}$$

$$\text{but B C} = \text{O B} \sin. z$$

$$\text{and A C} = \text{O C} \cos. x$$

$$= \text{O B} \cos. z \cos. x$$

$$\therefore \tan. y = \frac{\tan. z}{\cos. x} = \tan. z \sec. x$$

or to radius r

$$(1)\ r \tan. y = \tan. z \sec. x$$

and $\therefore$

$$\log. \tan. y = \log. \tan. z + \log. \sec. x - 10$$

$$(2)\ \text{or } \tan. z = r \frac{\tan. y}{\sec. x}$$

$$\therefore \log. \tan. z = 10 + \log. \tan. y - \log. \sec. x$$

(1) Giving the *true* dip if the apparent dip were observed in a cliff.

(2) Giving the *apparent* dip that ought to be drawn in the section when the true dip is known.

From this formula the following table has been calculated :—

Oblique Section Table.

Angle between the direction of the dip and that of the section.	Angle of the dip.															
	10°	15°	20°	25°	30°	35°	40°	45°	50°	55°	60°	65°	70°	75°	80°	85°	89°
10°	9° 51′	14° 47′	19° 43′	24° 40′	29° 37′	34° 36′	39° 34′	44° 34′	49° 34′	54° 35′	59° 37′	64° 40′	69° 43′	74° 47′	79° 51′	84° 56′	89° 59′
15°	9° 40′	14° 31′	19° 23′	24° 15′	29° 9′	34° 4′	39° 2′	44° 1′	49° 1′	54° 4′	59° 8′	64° 14′	69° 21′	74° 30′	79° 39′	84° 50′	88° 58′
20°	9° 24′	14° 8′	18° 53′	23° 39′	28° 29′	33° 21′	38° 15′	43° 13′	48° 14′	53° 19′	58° 26′	63° 36′	68° 49′	74° 5′	79° 22′	84° 41′	88° 56′
25°	9° 5′	13° 39′	18° 15′	22° 55′	27° 37′	32° 24′	37° 15′	42° 11′	47° 12′	52° 18′	57° 30′	62° 46′	68° 7′	73° 32′	78° 59′	84° 29′	88° 54′
30°	8° 41′	13° 4′	17° 30′	22° 0′	26° 34′	31° 14′	36° 0′	40° 54′	45° 54′	51° 3′	56° 19′	61° 42′	67° 12′	72° 48′	78° 29′	84° 14′	88° 51′
35°	8° 13′	12° 23′	16° 36′	20° 54′	25° 18′	29° 50′	34° 30′	39° 19′	44° 19′	49° 29′	54° 49′	60° 21′	66° 3′	71° 53′	77° 51′	83° 54′	88° 47′
40°	7° 41′	11° 30′	15° 35′	19° 39′	23° 51′	28° 12′	32° 44′	37° 27′	42° 23′	47° 38′	53° 0′	58° 40′	64° 35′	70° 43′	77° 2′	83° 29′	88° 42′
45°	7° 6′	10° 4′	14° 25′	18° 15′	22° 12′	26° 20′	30° 41′	35° 16′	40° 7′	45° 17′	50° 46′	56° 36′	62° 46′	69° 14′	76° 0′	82° 57′	88° 35′
50°	6° 28′	9° 46′	13° 10′	16° 41′	20° 21′	24° 14′	28° 20′	32° 44′	37° 27′	42° 33′	48° 4′	54° 2′	60° 29′	67° 22′	74° 40′	82° 15′	88° 27′
55°	5° 46′	8° 44′	11° 48′	14° 59′	18° 19′	21° 53′	25° 42′	29° 50′	34° 21′	39° 20′	44° 49′	50° 53′	57° 36′	64° 58′	72° 55′	81° 20′	88° 15′
60°	5° 2′	7° 38′	10° 19′	13° 7′	16° 6′	19° 18′	22° 45′	26° 33′	30° 47′	35° 32′	40° 54′	46° 59′	53° 57′	61° 49′	70° 34′	80° 5′	88° 0′
65°	4° 15′	6° 28′	8° 45′	11° 9′	13° 43′	16° 29′	19° 31′	22° 55′	26° 44′	31° 7′	36° 12′	42° 11′	49° 16′	57° 37′	67° 21′	78° 19′	87° 38′
70°	3° 27′	5° 14′	7° 6′	9° 3′	11° 10′	13° 26′	16° 0′	18° 53′	22° 11′	26° 2′	30° 39′	36° 15′	43° 13′	51° 55′	62° 43′	75° 39′	87° 5′
75°	2° 37′	3° 59′	5° 23′	6° 53′	8° 30′	10° 16′	12° 15′	14° 30′	17° 9′	20° 17′	24° 8′	29° 2′	35° 25′	44° 1′	55° 44′	71° 20′	86° 9′
80°	1° 45′	2° 40′	3° 37′	4° 37′	5° 44′	6° 56′	8° 17′	9° 51′	11° 41′	13° 55′	16° 41′	20° 25′	25° 30′	32° 57′	44° 33′	63° 15′	84° 15′
85°	0° 53′	1° 20′	1° 49′	2° 20′	2° 53′	3° 30′	4° 11′	4° 59′	5° 56′	7° 6′	8° 35′	10° 35′	13° 28′	18° 1′	26° 18′	44° 54′	78° 41′
89°	0° 10′	0° 16′	0° 22′	0° 29′	0° 35′	0° 42′	0° 50′	1° 0′	1° 11′	1° 26′	1° 44′	2° 9′	2° 45′	3° 44′	5° 39′	11° 17′	44° 59′

The use of this table is obvious without much explanation. A single example will suffice. Suppose a section be drawn running north-east and south-west, and it crosses certain beds dipping north at 35° (or certain cleavage planes, or a vein, or a fault, or any other plane having that dip), what angle ought we to give to those beds in the section in order to give a true representation of the apparent dip they would have in a cliff running parallel to the section?

In this case the angle between the direction of the dip and that of the section, or between north and north-east $=45°$, which we look for in the vertical column on the left of the table, the angle of the dip $=35°$, which we find in the horizontal column at the top of the table. At the intersection of these two lines in the body of the table we should find 26° 15′, the angle required.

In practice the minutes of the angle are never required, but as it involved no extra trouble to insert them they are given, as the table might possibly be of use in other ways where more minute accuracy is requisite.

It is plain that the table can be equally used to find the *true* dip where the *apparent* dip only can be observed in a real cliff, provided the angle between the line of section and the strike (and therefore the true dip) of the beds can be ascertained. This, however, is a case which rarely occurs in practice. When it does, of course the nearest angle to the observed apparent dip will be sought in the body of the table, on the line opposite to the angle between the direction of the cliff and that of the strike $\pm 90°$, and the angle of the real dip answering to it will be found at the top of the table.

Note on the Stigmaria Beds of the South Staffordshire Coal Field. By Sir Henry de la Beche, C.B., F.R.S., &c.

The coal-field of South Staffordshire forms no exception to the other coal-fields of Great Britain as regards the occurrence, in certain of its beds, of the peculiar fossil roots, known as *stigmaria*, in their relative places o growth. These vegetable remains, long considered as the stems of a distinct fossil plant, are now known, chiefly through the researches of Mr. Binney,* in England, and of Mr. Brown † in Nova Scotia, to be the roots of the fossil genus *sigillaria*, or of some other of the like kind of plants.

Mr. Steinhauer would appear (in 1818) to have been the first to have observed the mode of occurrence of *stigmaria* in certain beds of the coal measures, in a manner pointing to their growth in the bed where they are thus found. Speaking of the rootlets or fibres, as he terms them, diverging from the main *stigmaria* root, he remarks that "on examining the projecting ends of some trunks (of *stigmaria*) which lay horizontally in a bed of clay, extending along the southern bank of the rivulet which separates the townships of Putsey and Tong, and which is exposed in several places it excited no little surprise to find traces of these fibres proceeding from the centre cylinder in rays through the stratum in every direction, to the distance of twenty feet." He further inferred that these fibres or rootlets "belong to the trunks in question, and, consequently, that the vegetable grew in its present horizontal position at a time that the stratum was in a state capable of supporting its vegetation, and shot out its fibres in every direction through the then yielding mud." ‡

Though the evidence on this head is common to all the coal fields of Great Britain, and can be so readily obtained in many localities, the subject did not engage much attention until Mr. William Edmond Logan, examining the coal measures of Glamorganshire and Caermarthenshire, was not only enabled to confirm the views of Mr. Steinhauer, but also to ascertain (in 1833) the important fact that all the coal beds of that district reposed on such beds. When the Geological Survey entered upon the examination of the coal measures in the vicinity of Swansea in 1837,

* Mr. Binney's observations respecting the trees discovered at St. Helen's, Lancashire, were made known to the meeting of the British Association for the Advancement of Science, in June 1845, and his description of the *sigillaria* terminating in *stigmaria*, found at Duckinfield, seven miles E. of Manchester, was read before the Geological Society of London, in April 1846, and published in their Quarterly Journal, with figures, vol. ii. p. 390.

† Mr. Brown read a paper before the Geological Society, on the same day (22d April 1852), with Mr. Binney's last-mentioned paper. It is also published in that Society's Journal, vol. ii., and is entitled "On a group of erect fossil trees, in the Sydney Coal Field at Cape Breton." He gives figures of an upright *sigillaria* stem with branching *stigmaria* roots.

‡ American Philosophical Transactions, new series, vol. i.

Mr. Logan pointed out the *stigmaria* beds as constantly beneath the coal.* In verifying the beautiful maps and sections of the western portion of the South Welsh coal field, which, with a generous love for the advancement of knowledge, Mr. Logan presented to the Geological Survey, and which were subsequently published by it, abundant opportunities were afforded for ascertaining the truth of this view, one still further confirmed, as might have been anticipated, by the general examination of the whole coal field of that portion of Great Britain. The Survey in its progress among many other coal fields of the country has always observed similar facts, and hitherto, including South Staffordshire, the connexion between coal and stigmaria beds has, with few exceptions, and many of these doubtful, been found constant.

Having had occasion to visit nearly all the coal measure districts of Great Britain, from those of Scotland on the north to those of Somersetshire on the south, inclusive, I twice visited the South Staffordshire coal field, and in all the cases where opportunities were afforded for examining the beds beneath the coal, found *stigmaria* in them occurring as in their relative places of growth. Dr. Joseph Hooker in 1847, (then botanist to the Geological Survey,†) having directed his attention at that time especially to the structure of *stigmaria*, and having had occasion, therefore, to examine into the subject with much detail, found these stigmaria beds common‡; Mr. Dawes, of Southwick House near Birmingham, who has given so much attention to the fossil botany of the district, considers that all the coal beds in it are based on stigmaria beds. §

In studying these beds care is needed in seeing that the rootlets of the *stigmaria* really diverge from the main root, and permeate the bed in which they may be discovered, in the manner which the roots of the water lily (as pointed out by Dr. Hooker) and those of many other aquatic plants permeate the silt beneath still waters. Portions of the main stigmaria roots and even of the rootlets are to be found in the other beds, washed out of their soils (stigmaria beds) and drifted like the stems of *sigillaria* to which they belonged. From not distinguishing between the *mode of occurrence* of the stigmaria and their rootlets in the different beds, the not unfrequent mistake has arisen of considering the remains of stigmaria as

* It was not until February 1840 that Mr. Logan communicated his knowledge of this circumstance to the Geological Society of London, in a paper entitled "On the Character of the Beds of Clay immediately below the Coal Seams of South Wales, and on the Occurrence of Boulders of Coal in the Pennant Grit of that District." This memoir was published in the Transactions of that Society, vol. vi., 1842.

† An appointment held by Dr. Hooker until his Botanical Mission, for the Government, to India, towards the end of 1847. The results of Dr. Hooker's researches are published in the Memoirs of the Geological Survey, vol. ii. part 2, p. 431, in a paper entitled "On some Peculiarities in the structure of Stigmaria."

‡ Subsequently Professor A. Ramsay (Local Director of the Geological Survey of Great Britain) and Mr. Warington Smyth (Mining Geologist to the Geological Survey of the United Kingdom) examined the stigmaria beds in their official visits to the district.

§ Dawes, MSS.

so diffused throughout the various coal measures, that no conclusion can be drawn respecting their mode of growth in place.

In South Staffordshire, as in the other coal-measure districts of Great Britain, the composition of the inorganic portions of the stigmaria beds varies considerably, as, indeed, might be anticipated from its detrital mode of accumulation. At the same time the number of instances in which the mineral matter of these beds is of a character to afford good materials for fire-bricks, and is hence known as *fire-clay*, is somewhat remarkable. By reference to the vertical sections of the Geological Survey, sheets 16, 17, and 18 (all relating to South Staffordshire), the numerous instances of fire-clays beneath the coal will be at once seen; and so far as my experience has extended the fire-clays so situated contain the stigmaria roots, with every appearance of growth in place. At times it requires careful observation to detect the stigmaria roots in the beds containing them, as well beneath the beds of coal, sufficiently important to have names assigned them, as beneath mere seams of an inch or two in thickness. As will be readily understood, even all traces of a coal above a stigmaria bed may be absent, either from the carbonaceous matter having been removed by the stream or current of water which deposited new matter, such as sand, above it, or from the conditions not having been so far advanced as to permit the stigmaria bed or soil to be coated over with such carbonaceous matter.*

Seeing the general occurrence of the stigmaria beds beneath those of coal, a proper appreciation of them may become, as it has been already found in some districts, practically useful in tracing the outcrop of beds, especially where the crop of a coal itself may be uncertain, and the thickness of a stigmaria bed may be considerable, though the latter necessarily, seeing the respective origin of the two, bears no relation to that of any coal which it may support, or be intermingled with.† When "fire-clays" contain the stigmaria roots, properly permeating their ancient soil, there is usually a

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* In some coal districts, as, for example, in South Wales, the carbonaceous matter, which formed the coal, has been sometimes entirely removed, and even channels cut in the supporting stigmaria beds, by the water which bore, and allowed the deposit of, the sand or silt now forming sandstones or arenaceous shales, covering the eroded and non-eroded parts: such erosion having taken place when the coaly matter was unconsolidated.

An excellent example of the erosion of coal into channels, like those amid some peat bogs, occurs in the Forest of Dean, where it is known as 'the Horse.' This 'Horse,' with its tributaries, named 'Lows,' will be found well described by the late distinguished colliery viewer, Mr. John Buddle, in the Transactions of the Geological Society of London, new series, vol. vi. p. 213. The memoir is accompanied by an illustrative plan and section.

† The intermingling of the stigmaria and coal beds or seams has often led to the supposition, especially when a stigmaria bed beneath any coal worked was rarely touched or examined, that these beds occurred quite as much above coal beds as beneath them, the roof of a given working being formed of a stigmaria bed. Illustrative instances of the interstratification of stigmaria with coal beds in South Wales, will be found in the Memoirs of the Geological Society, vol. i. p. 153.

little difficulty in practically tracing their crop, but when the mineral matter of these beds takes the more ordinary form of a sandstone or arenaceous shale, the case is different. Then an examination of the mode of occurrence of the stigmaria roots themselves is essential, especially when the lithological character of the bed may be liable to change, and in some coal districts we have been enabled to trace the same stigmaria bed from the ordinary condition of a fire-clay to a rock in which the arenaceous matter greatly prevailed.*

Note on the Mode of working the Coal and Ironstone of South Staffordshire. By Warington W. Smyth, M.A., Mining Geologist to the Geological Survey.

A brief sketch of the modes of working the beds of coal and ironstone in South Staffordshire is appended, with a view of recording generally the practical methods, adopted at the present time, for the extraction of those rich stores of mineral wealth of which the geological relations have been described in the preceding pages.

The acknowledged requisite for the most advantageous method of working, viz. the combination of the cheapest mode of extracting the greatest possible quantity of mineral, with the safety and comfort of the men, has in this district been greatly modified by the circumstances of position, and an adherence to long established customs. In a few rare instances only have any attempts been made to substitute a new system for the old routine, and to such it will be needful to advert after we have viewed the principal features of the practice almost universally followed.

In the first place, the division of the ground into separate works is guided by the faults which in so many instances constitute natural boundaries and by the depth from the surface, of the deposits proposed to be worked; and an observer, conversant with districts of coal where extensive unbroken areas are worked at great depths by few shafts, cannot fail to be struck with the appearance of the South Staffordshire field, dotted over as it is with innumerable shafts, and deformed by the large waste heaps of slate and slack which so frequently surround them. The cause of this, lying in the subdivision into small areas, and the comparative shallowness of the workings, and conducive no doubt to simplicity in all the internal arrangements, affords such facilities for securing the desiderata above alluded to, that it must be a matter of surprise to find that certain ancient incomplete usages should so long have held their ground.

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* The consolidation of stigmaria beds is occasionally very considerable, even approaching that of quartz rock. Good examples of stigmaria beds thus consolidated may be seen on the coast (at Lilliput) near Swansea, where from the infiltration of silica, two beds, each supporting small beds of coal, and penetrated by stigmaria roots and rootlets in their relative places of growth, have become hard quartz rocks.

The shafts by which access to the coal and ironstone measures is to be obtained, are sunk two together, at a distance of 6 or 8 yards asunder, and with a diameter of 6 or 8 feet. Each shaft being intended for a single rope or "band," is surmounted by a head-frame carrying one broad pulley of cast iron, and the whimsey engine is so placed as to be able to serve two shafts at once, raising a loaded "skip," in the one, and lowering an empty one in the other, at the same time. The difficulties of sinking, as regards watery strata, being inconsiderable, except in some few cases, the ingenious and expensive application of wooden or iron tubbing, practised so frequently in the Belgian, and in our northern coal fields, is almost unknown; and the shafts are lined with brick work, unless when they pass through strata sufficiently strong to stand permanently without support. The area of the shafts is free from any obstruction, no "guides" being employed to regulate the passages of the "skips" or frames upon which the coal is piled in large masses surrounded by loose "rings," of sheet iron, and from which less than might be expected falls off during the ascent. Ponderous flat chains of three links, alternately short and long, with slips of wood inserted through the long links, are most frequently used for the drawing, and for shafts of moderate depth are very effective and safe.

Taken apart from minor details the modes of working the mines are two in number, the first applied to the important beds called the "thick coal," and the "new mine;" and the second, termed "long work," (not like the former, peculiar to the district,) employed in the other coal seams of from two to five feet in thickness, and in the ironstone measures.

The workings of the ten-yard coal are divided into compartments termed *sides of work*, which are separated from one another by "ribs," or walls of coal, from 8 to 10 yards thick, and of which no more are kept open at once than can be maintained in activity.

From the main roads, termed *gate roads*, each *side of work*, unless commenced near the outer boundary, is accessible only through a narrow opening, cut, like the gate road itself, in the lower part of the seam. "Stalls" are then driven out in the coal, each of them 8 or 10 yards wide, and are crossed again by similar galleries, leaving between them pillars of 8 or 10 yards square, but varied of course in dimension, according to local circumstances. For additional security during the working, small pillars of 3 or 4 yards square at the base, termed *men of war*, are spared out of the solid coal, wherever it is deemed necessary, to be rapidly prostrated and carried off, when the stall is fully opened. But the driving of the stalls themselves is a work involving no little waste of coal and insecurity to the colliers; the mass of coal of 8 yards wide having to be undercut, or *holed* about a couple of yards in, a large amount of coal is cut up into slack by the "pike," or collier's pick, and the men are exposed to continual risk from falls of coal. As the various portions of the seam are successively "cut" at the side of the stall, and brought down, the colliers have to mount on heaps of slack or light wooden stages, and are necessarily exposed to still greater danger.

There is, in fact, perhaps scarcely any situation more suggestive of feelings of awe, than a side of work in the "thick seam," when a large fall of coal is brought down from the dusky heights of that lofty chamber; the thunder of the falling masses which seem to shake the solid earth and fill the air with a thick cloud of dust, contrasting fearfully with the dead silence which ensues, and which the hardy colliers scarce break by a whisper, whilst in suspense they listen for the slightest crack which might portend a farther fall.

When a compartment has thus been cleared and the large pillars sometimes a little thinned, the "slack" or small coal and dust is left in heaps, and to guard against the spontaneous combustion, apt to ensue from the decomposition of small particles of pyrites, a dam is placed in the "bolt hole," and this portion cut off from all communication with the rest of the workings.

The second mode of getting, by what is called long-work, need not be described at length, being very similar to that practised in Shropshire, Derbyshire, and other districts; it is, as elsewhere, variable according to the conditions of the roof, &c., the road-ways being sometimes driven out through the "whole coal," which is then worked back towards the shafts, in other cases the roads being maintained through the "gob" or waste from which the coal has been removed, as the extraction proceeds from the shafts towards the limits of the field.

Very important, however, in an economical point of view, both to the lord of the soil, and to the lessee, as well as to the interests of humanity, is the success which has attended the efforts of certain coal owners to get the ten-yard-coal on the principles of "long-work," as exemplified in the pits of the Messrs. Foster, of Mr. Gibbons, and at Corngreaves. We have seen that by the usual method, what with the ribs and pillars left untouched and the quantity of coal cut up into slack, a vast amount of useful fuel—of what in fact in a very few years *must* become of much higher value, is utterly lost to the nation.

It is not too much to assert, that from $\frac{1}{3}$ to $\frac{1}{2}$ of the coal is thus left useless, (some little only of the ribs and pillars being afterwards recoverable in a damaged condition), an amount of squandered natural advantages almost without a parallel.

By the common plan it is considered that 16,000 tons of coal obtained from an acre of ground represents a very fair produce, and no doubt a very much lower number is often obtained. At Messrs. Foster's, the coal is worked in two divisions, the upper half first, by long-work, and then some months afterwards, when the "shut" or roof has fully subsided, the lower half is worked by the same method, and a total amount of from 26,000 to 31,000 tons of coal to the acre is procurable, and it need only be added to the conclusions suggested by a comparison of these numbers, that, under this newly applied system, there has been enjoyed a comparative immunity from those frequent and frightful accidents which have gained the workings of the thick coal a most unenviable notoriety.

In conclusion, the ventilation of these works requires a short notice, from the fact, that although the coal is not highly charged with fire-damp, very serious accidents have happened from explosions, and the every day state of some of the pits cannot be regarded without dread. The establishment of a current of air is left much to accident; and the causes disposing the air to travel down one shaft and up the other are so easily disturbed by a change of wind, or other trivial cause, that a stagnation is frequently produced, or the pits are said to *fight*, and during the contest, if nothing more serious occurs, the colliers are obliged to "play" or absent themselves.

"Air-heads," of not more than 9 or 10 feet sectional area, are driven in the coal parallel with the gate roads, and communicate with the "sides of work;" but unless, according to the suggestion of Ryan, they are driven in the upper part of the seam, there must frequently accumulate in those high working stalls a magazine of explosive gas ready to fire on the first opportunity, so easily afforded by a fall of coal, a change in the barometer, or the imprudence of a workman.

It need scarcely be observed how greatly the danger is augmented, when the "air-heads" are not brought up simultaneously with the main workings, yet under the "butty" or "chartermaster" system, it is too common to find those important works omitted for long distances, and the men working in a confined space charged with foul gases and fire-damp almost to the explosive point.

A great deal might be said on the details of this and the previous subjects, but I would hope that these short notes may only serve as a record of rude practices soon to be improved, and must refer the reader, desirous of further information on these heads, to the evidence before the committee of the House of Commons in 1835, of the House of Lords in 1849, to the report of Mr. J. Kenyon Blackwell, to Smith's Miner's Guide, published in 1836, and to Mr. Gibbons's pamphlet on his method of ventilation. No one, I believe, even practically unacquainted with the subject, will rise from the perusal of those statements without feeling that in the waste of a treasure of unique richness, and in the abandonment of an energetic and honest class of workmen to the dangers resulting from the absence of mental training, we have hitherto deserved as a nation but little credit for the stewardship of some of our finest coal-fields.

Note on the Coal raised and Iron made at present (December 1852) in South Staffordshire. By Robert Hunt, Keeper of Mining Records, Museum of Practical Geology.

From information kindly furnished by Mr. Kenyon Blackwell and by Mr. Samuel Blackwell, of Russell's Hall iron works, Dudley, we are enabled to append the following statements respecting the coal raised and iron made in South Staffordshre.

The quantity of coal altogether raised in South Staffordshire may be

estimated at from 5,000,000 to 5,500,000 tons per annum, the present value of which may be taken at about 2,500,000*l.* sterling.*

The quantity of coal required for calcining and for smelting the iron ore is at the rate of about three tons for one ton of pig iron, or about 1,950,000 tons annually employed for this purpose.

The average production of iron from the clay iron-stone ore of the South Staffordshire coal measures may be estimated at about 33 per cent.

The quantity of pig iron produced per annum in South Staffordshire is 650,000 tons, which at the present price of iron (December 1852) may be valued at about 3,000,000*l.* sterling.

The quantity of bar iron made is at the rate of 500,000 tons per annum, the value of which may be estimated at 5,500,000*l.*, in consequence of the late great advance in the price of iron.

The number of furnaces now in blast in that district, according to the subjoined table, is at present 127, while 32 only are out of blast.

The number of mills and furnaces, according to the 2d table, are 1,469.

BLAST FURNACES in SOUTH STAFFORDSHIRE, December 1852.

Name of Works.	Proprietors.	In.	Out.
Pelsall	W. Fryer	1	1
Hatherton	Do.	1	1
Old Birch Hills	P. Williams & Sons	1	1
New Birch Hills	G. Jones	3	1
Bentley Heath	Countess of Lichfield	0	4
Darlaston Green	S. Mills	3	0
New Darlaston	Addenbrooke & Co.	2	0
Darlaston	D. Jones	1	0
Chillington	Chillington Company	4	0
Moseley	Ditto	3	0
Stow Heath	W. Sparrow & Co.	3	2
Osier Bed	Osier Bed Company	3	0
Priestfield	Executors of W. Ward	2	1
Millfield	W. Riley	2	1
Wolverhampton	Whitehouse & Poole	2	1
Parkfield	Parkfield Company	3	1
Bilston Brook	G. Hickman & Son	2	0
Bilston New Furnaces	Blackwell & Co.	2	0
	Carried forward	38	14

* The following were prices of the different coals at Lord Ward's collieries near Dudley, in December 1852:—

Thick or Ten-Yard Coal.

	s.	d.	
Best large coal	13	0	per ton.
Common ditto	11	0	„
Furnace ditto	11	0	„
Brazil and Patchells	9	0	„
Rough slack	10	0	„
Engine slack	4	6	„
Fine siftings	3	0	„

Heathen Coal.

	s.	d.	
Large coal	12	0	per ton.

Brooch Coal.

Large coal	12	0	„
Lumps	11	0	„
Kibbles	9	0	„
Slack	3	6	„

Blast Furnaces in South Staffordshire, December 1852—*continued.*

Name of Works.	Proprietors.	In.	Out.
	Brought forward - -	38	14
Bouvereux - -	Baldwin & Co. - -	2	0
Stonefield - -	T. W. Vernon - -	0	1
Bilston - - -	G. Jones - - -	3	0
Cosceley - - -	I. & T. Tarley - -	2	0
Priorfields - -	H. B. Whitehouse - -	3	0
Deepfields - -	Benton & Pemberton -	2	0
Do. - -	Groucutt & Co. - -	1	0
Caponfield - -	I. Bagnall & Sons - -	3	0
Ettingshall - -	T. Banks & Son - -	1	1
Hallfields - - -	B. Gibbons, jun. - -	1	0
Wednesbury Old Park -	Lloyds, Foster, & Co. -	2	0
Broadwaters - -	Colbourn, Groucutt, & Co. -	2	0
Wednesbury Oak -	P. Williams & Co. - -	3	0
Willingsworth - -	Haines & Co. - -	2	1
Crookhay - -	T. Davies & Son - -	3	0
Golds Hill - -	I. Bagnall & Sons - -	3	0
Tollend - - -	Tollend Company - -	1	0
Horseley - -	Colbourn & Co. - -	2	0
Tipton Green - -	Gibbons & Roberts -	2	0
Tipton - - -	Cresswell & Sons - -	1	1
Park Lane - -	T. Morris & Son - -	1	1
Dudley Port - -	Hopkins & Son - -	2	0
Coneygree - -	Lord Ward - -	2	1
Oldbury - - -	W. Bennitt - -	2	1
Union - - -	P. Williams & Sons -	3	0
Russell's Hall - -	Blackwell & Co. - -	3	0
Oak Farm - -	G. Bennet & Co. - -	2	0
Shutend - - -	J. Bradley & Co. - -	4	0
Ketleys - - -	B. Gibbons - -	3	0
Corbyn's Hall, New Furnaces.	Ditto - -	3	0
Do. - - -	Hall, Holcroft, & Pearson -	1	0
Corbyn's Hall - -	W. Mathews - -	3	1
Lays - - -	Firmstone & Co. - -	3	0
Brettell Lane - -	Hall, Holcroft, & Pearson -	1	1
Old Level - -	Ditto - -	1	1
Level - - -	Lord Ward - -	2	1
Woodside - -	Cochrane & Co. - -	2	0
Netherton - -	M. & W. Grazebrook -	1	1
Parkhead - -	Evers and Martin - -	1	1
Dixon's Green - -	J. Haden - - -	1	1
Windmill End - -	W. Haden - - -	1	1
Withymoor - -	Withymoor Company -	1	1
Bumble Hole - -	New British Iron Company	2	0
Dudley Wood - -	Ditto - -	2	2
Corngreaves - -	Ditto - -	2	0
Old Hill - - -	T. & I. Badger - -	1	0
	Total - -	127	32

List of Mills and Forges, South Staffordshire, December 1852.

——	Name of Work.	Proprietors.	No. of Puddling Furnaces.
Walsall -	Pelsall Iron Works - -	Davis and Bloomer - -	11
	Wedges Mills - -	Gilpin & Co. - -	10
	Walsall - - -	C. Lancaster - -	6
Wolverhampton	Shrubbery - -	G. B. Thorneycroft & Co. }	40
	New Shrubbery - -	G. B. Thorneycroft & Co. }	
	Swan Garden - -	G. B. Thorneycroft & Co. -	20
	Chillington - -	Chillington Iron Company -	45
	Horseley Field Tin Plate Works.	Baldwin & Co. - -	6
	Horseley Field - -	Osier Bed Company -	12
	Minerva - - -	John Jenks - - -	10
Darlaston -	Darlaston - - -	Samuel Mills - -	18
	Darlaston - - -	David Rose - -	*
	Moxley - - -	Daniel Rose - -	8
	Moxley - - -	Thomas Mills - -	8
	Bullbridge - -	John Gettings - -	4
	Darlaston Green - -	David Jones - -	†
Bilston - -	Bilston Bridge - -	David Jones - - -	10
	Bankfield - -	Colbourn & Co. - -	14
	Bradley Field Iron Works -	Rose, Higgins, and Rose -	18
	Regent Iron Works -	Hobson & Co. - -	6
	Caponfield - -	Chillington Iron Company -	20
	Bradley - - -	Chillington Iron Company -	14
	Bradley - - -	G. B. Thorneycroft & Co. -	13
	Stonefield - - -	T. W. Vernon - -	11
	Bilston Forge - -	George Jones - -	14
	Spring Vale - -	George Jones - -	32
	Bilston Mill - -	W. and J. S. Sparrow -	26
	Ettingshall - - -	Thomas Banks & Son -	15
	Deepfield - - -	Browning & Iliffe - -	12
	Deepfield - - -	Thompson & Co. - -	*
	Highfield - - -	W. Riley - - -	30
Wednesbury -	Lea Brook - - -	James Solley - -	22
	Lea Brook - -	John Bagnall & Sons -	13
	Lea Brook - - -	Chillington Iron Company -	30
	Imperial - - -	John Bagnall & Sons -	14
	Wednesbury Iron Works -	George Adams - -	4
	Monway Green - -	John Marshall - -	9
	Kings Hill Field - -	John Russell - -	6
	Brunswick Iron Works -	Patent Shaft Company -	20
	Victoria - - -	Fletcher, Rose, & Co. -	14
Tipton - -	Wednesbury Oak - -	P. Williams & Sons -	30
	Gospel Oak - -	J. and E. Walker - -	14
	Tipton Old Church - -	J. and E. Walker - -	14
	Summerhill - -	W. Millington & Co. -	12
	Bloomfield - -	Barrows & Hall - -	46
	Tipton Green - -	Barrows & Hall - -	11
	Factory - - -	Welch, Barrows, & Co. -	14
	Tipton - - -	Edward Creswell & Sons -	22
	Dudley Port - - -	Plant & Fisher - -	17
	Old Dudley Port - -	Frederick Giles & Co. -	12
	Great Budge - -	Eagle Coal and Iron Company.	10
		Carried forward -	759

* Mill only. † Building.

List of Mills and Forges, South Staffordshire—*continued.*

——	Name of Work.	Proprietors.	No. of Puddling Furnaces.
		Brought forward -	759
	Tividale - - -	Tividale Iron Company -	12
	Dudley Port - -	Frederick Giles & Co. -	10
	Tividale - - -	E. B. Whitehead - -	*
Westbromwich -	Golds Hill - - -	John Bagnall & Sons -	15
	Toll End - - -	John Bagnall & Sons -	15
	New Golds Hill - -	Davis and Bloomer -	12
	Atlas - - -	Atlas Iron Company -	12
	Crookhay - - -	Thomas Davis & Co. -	38
	Ridgacie - - -	John Whitehouse . - -	15
	Hall End - - -	T. Johnson - -	7
	Smethwick Works - -	John Williams & Co. -	19
	District Works - -	Beasleys and Farmer -	20
	Crown Forge - -	George Downing - -	12
	Providence - - -	Silvester and Jackson -	16
	Anchor Iron Works -	James Boydell - -	10
	Spin Lane - -	James Gregory - -	8
	Phœnix - - -	Whitehouse & Co. - -	24
	Victoria - - -	David Hopkins & Sons -	6
	Greets Green - -	Eagle Coal and Iron Company.	14
	Sheepwash - - -	Hunt & Co. - -	6
	Roway - - -	Edward Page & Sons -	19
	Albion - - -	Walter Williams - -	32
	Bromford - - -	John Dawes & Sons -	30
Oldbury -	Brades - - -	W. Hunt & Sons - -	6
EAST WORCESTERSHIRE:			
Dudley -	Dixons Green - -	Wm. Haden - -	14
	Corngreaves - -	British Iron Company -	30
	Nine Locks - - -	British Iron Company -	20
	Cradley - - -	Samuel Evers & Sons -	11
	Brockmoor - - -	John Bradley & Co. - }	20
	Brierley - - -	John Bradley & Co. - }	
	Brettell Lane - -	John Wheeley & Co.	*
	Brockmoor - -	John Wheeley & Co. -	14
	Lays - - -	Brown and Freer - -	20
	Lays New Works - -	Budd & Co. - -	11
	Harts Hill - -	W. Jeffrie - -	12
	Level - - -	Hall, Holcroft, & Pearson -	18
Kingswinford -	Corbyns Hall - -	W. Matthews - -	19
	Shut End - -	John Bradley & Co. -	30
	Oak Farm - -	Williams & Co. - -	25
Stourbridge -	Stourbridge - - -	John Bradley & Co. -	30
	Gothersley - -	Gothersley Iron Company -	*
	Whittington - - -	Williams & Co. - -	10
	Hyde - - -	Lee & Bolton - -	12
Kidderminster -	Cookley - - -	Cookley Iron Company -	25
	Wilden - - -	Wilden Iron Company -	8
	Broadwaters - -	Morgan Banks & Co. -	8
			1,462

* Mill only. † Building.

NOTE.

The following extracts from Plot's Natural History of Staffordshire, published in 1686, may serve to show the state of the South Staffordshire district, as regarded its coal and iron at that time. Speaking of the common coal then raised at Wednesbury, Dudley, and Sedgeley, Dr. Plot says, "of which sort there is so great plenty in all parts of the country, "(especially about the three above mentioned places), that most commonly there are 12 "or 14 *colery's* in work, and twice as many out of work, within 10 miles round, some "of which afford 2,000 tuns of coal yearly, others three, four, or five thousand tuns. "The upper or topmost beds above the ironstone lying sometimes ten, eleven, or twelve "yards thick. * * * * * Nor indeed could the country well subsist without "such vast supplies, the wood being most of it spent upon the ironworks."

Alluding to the attempts which were made to smelt iron with coal or coke, he says, "The last effort that was made in this country for making iron with pit coal, was also "with raw coal, by one *Mr. Blewstone*, a high *German*, who built his furnace at Wednes-"bury, so ingeniously contrived that only the flame of the *coal* should come to the *oare* with "severall other conveniences, that many were of opinion he would succeed in it. But "experience, that great baffler of speculation, showed it would not be. The sulphureous "vitriolic steams that issue from the pyrites, which frequently, if not always, accom-"panies *pit coal*, ascending with the flame, and poysoning the *ore* sufficiently to make it "render much worse *iron*, than that made with *char-coal*, though not perhaps so much "worse, as the body of *coal* it-self would possibly doe."

The different kinds of iron made are mentioned under the heads of 1, Redshare; 2. Coldshare; 3. Blend metell; and tough iron, the last being the best, and cheifly made from ores obtained at Rushall. The ores were first calcined on the open ground, "with "small charcoal, wood, or sea-cole." After this they were taken to the blast furnace, where they were smelted with charcoal, one basket of the latter being used to one basket of calcined ore. The iron run from the furnaces was then taken to the forges, which were of two kinds, one known as the Finery, the other as the Chafery, and made into bars. For cutting the iron into rods it was taken to Slitting mills, and there cut and rolled.

Speaking of the improvement then made in iron smelting, Dr. Plot remarks, "we shall "find it very great, if we look back upon the *methods* of our *ancestors*, who made "*iron* in *foot blasts*, or *bloomeries*, by mens treading the bellows, by which way they could "make but one little lump or *bloom* of *iron* in a day, not 100 weight, leaving as much "*iron* in the *slag* as they get out. Whereas now they will make two or three tuns of "*cast iron* in 24 hours; leaving the *slag* so poore, that the founders cannot melt them "again to profit. Not to mention the vast advantage they have from the new invention "of *slitting mills*, for cutting these barrs into rodds, above what they had antiently."

It would appear that the first successful smelting of iron ore by means of coal, then usually called pit or sea coal, was effected by Dud Dudley in the year 1619. Other unsuccessful attempts by Simon Sturtevant, John Rovenson, and others having been previously made.

Dud Dudley in his book Metallum Martis, 1665, says, that having been taken from Baliol College, Oxford, where he was then a student, in 1619; "to look and manage 3 "iron works of my fathers, 1 furnace, and 2 forges, in the Chase of Pensnet, in "Worcester-shire, but Wood and Charcole, growing then scant, and Pit-coles in great "quantities abounding near the furnace, did induce me to alter my furnace, and to attempt "by my new invention, the making of iron with pit-cole, assuring myself in my invention, "the loss to me could not be greater then others, nor so great, although my success "should prove fruitless; but I found such success at first tryal animated me, for at my "tryal or blast I made iron to profit with pit-cole, and found *Facere est addere Inven-*"*tioni*, * * *

" After I had made a second blast and tryal the fesibility of making iron with pit-cole " and sea-cole I found by my new invention, the quality to be good and profitable, but the " quantity did not exceed above 3 tuns per week."

A patent for smelting iron ore by pit or sea coal was granted to Dud Dudley in 1619. In the year following his works were swept away by a great flood, known for long afterwards as the May-day flood.

We, however, find Dud Dudley stating that the works were repaired, and that he " made annually great store of iron, good and merchantable, and sold it to divers men, yet living (1665) at twelve pounds per tun." Making " all sorts of cast iron wares, as " brewing-cysterns, pots, morters, and better and cheaper than any yet were made in " these nations with charcoles." Subsequently we find him smelting with pit-cole at Himley Furnace, Staffordshire, having been " outed of his works and inventions before-mentioned by the iron masters and others wrongfully," and again at Hasco-Bridge in the parish of Sedgley, Staffordshire, making seven tons of iron per week—" the greatest " quantity of pit-cole iron that ever yet was made in Great Britain.

Dud Dudley's works were riotously destroyed, and he himself by adhering to the royal cause became utterly ruined.

As respects the prices of the iron made by Dud Dudley, he states that " he did sell pig " or cast iron made with pit-cole at four pounds per tun, many tuns, in the twentieth year " of King James with good profit." He further says—" The author did sell bar iron good " and merchantable, at twelve pounds per tun and under, but since bar iron hath been sold " for the most part ever since at 15*l.*, 16*l.*, 17*l.* and 18*l.* per tun by charcoal iron " masters."—*Metallum Martis*, p. 32.